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Influence of Personal and State Level Variables on Perception of State Emergency Management Network Resilience In 47 States

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INFLUENCE OF PERSONAL AND STATE LEVEL VARIABLES ON PERCEPTION OF STATE EMERGENCY MANAGEMENT NETWORK RESILIENCE IN 47 STATES

by

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ABSTRACT

Emergency management coordination in the United States has fallen victim to over a century of strategies to organize, reorganize, consolidate, or decentralize disaster preparedness, planning and response. Regardless of the agency in charge at the federal level, individual citizens have been responsible for their own well-being immediately after any disaster or emergency event for more than 100 years because it takes time to mobilize and deliver aid. The system most often charged with managing that mobilization during an emergency event that exceeds the response capacity of local public safety agencies is the state emergency management network. Many entities in a state emergency management network have different responsibilities during disaster states vs. non-disaster states. Regardless of their role and function, entities need to be able to exchange resources and information with each other, often under time, economic, or other constraints during disasters. This resource exchange generates trust, an essential element of a resilient network. Resilient networks suffer fewer negative impacts from disaster related loss and are more likely to retain collective capacity to respond and help communities recover.

"The purpose of this study is to explore the ability of individual and state level attributes to explain variability in perception of network resilience. One-hundred fifty one state emergency management agency employees were surveyed regarding their perception of 5 constructs of network resilience (rapidity, redundancy, relationships, resourcefulness, and robustness) and individual level attributes. State level indicators from FEMA, NEMA, American Human Development Index, and Social Vulnerability Index were also analyzed.

Overall, it was found that the individual attribute of perception of network integrity had the most influence on perception of network resilience, followed by perception of community

resilience and state level attributes including disaster experience, state well-being, and number of full time state emergency management agency employees. These findings can improve network resilience by informing state emergency management network development activity. Networks that increase member opportunities to develop relationships of resource and information exchange will increase their resilience. That increased network resilience impacts community resilience because, as Winston Churchill's wise words during World War II reconstruction advise, "We shape our communities and then they shape us".

With grateful appreciation to my parents for their faithful love and trusting support of me and my family up and down the East Coast during this doctoral decade. To my children, for their willingness to do whatever needed doing, wherever it needed to be done so I could study, learn, grow, and pay it forward. To my small inner circle of amazing people for their encouragement, proofreading, and steadfast belief that I could finish.

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CHAPTER ONE: INTRODUCTION

Background

The evening news is rarely without devastating imagery of a hurricane, earthquake, tornado, or wildfire somewhere in the world. While recent media coverage has reported horrific loss from China to Haiti, the top 10 most expensive *world-wide* disasters in the last 110 years have all occurred in the United States within the last two decades, with a total economic impact for all U.S. disasters between 1991 and 2005 estimated at over 365 billion dollars (UN/ISDR, n.d.). In the United States, the number of presidential disaster declarations increased from 162 in the decade between 1956 and 1965 to 597 in the decade between 2001 and 2010 (FEMA, 2012). These escalating costs come during a period of corresponding economic distress, placing ever increasing strain on federal, state, and local emergency response agencies.

Given the rising number of disaster declarations and the costs associated with them, it is timely to explore the potential for new strategies to reduce community vulnerability and decrease the cost of these impacts. Improving disaster management efficiency and effectiveness requires strategies that offer better organization, more concerted effort, and substantial reallocation of resources (Alexander, 2006). One promising strategy to improve emergency management organization and efficiency is to employ the tried and true business adage “Use the right people for the right job”. The government level that has the “right people” to provide an emergency function is the level that has [access to] appropriate equipment and sufficient management capacity while still being close to the ground and in the midst of the emergency event (Haddow & Bullock, 2006). In the United States, this is often the state government level, where officials can draw information and intelligence down from larger national sources and coordinate the mobilization of personnel and equipment at local levels. State emergency management agencies are positioned to be the most efficient nexus of coordination, communication, and exchange between localities and state and federal emergency management resources. In light of the increasing incidence of disaster declarations in the United States and increasing costs associated with each response, it is imperative that more efficient use of available resources be explored. Goldsmith and Eggers (2004) suggest that a critical governance priority is the need to reconcile outmoded vertical tools of authority with horizontal tools of action, like networks.

This research is predicated on the assumption that development of network resilience is a viable strategy to reduce community vulnerability. Improved network performance is purported to reduce the negative impacts of disaster events by decreasing community risk, increasing community resilience and increasing state emergency network capacity to both respond and help communities recover. This purpose of this study is to explore individual and state level predictors of network resilience to inform that process. Specific aims of the study include:

- Aim 1: To determine if network resilience is validly measured by the constructs of redundancy, rapidity, resourcefulness, robustness and relationships.
- Aim 2: To determine if specific individual level indicators can predict perception of emergency management network resilience.
- Aim 3: To determine if specific state level indicators can predict perception of state emergency management network resilience.
- Aim 4: To determine if state level variables are more influential than individual-level variables in explaining the variability in perceived emergency network resilience.

Statement of the Problem

Organizing is what you do before you do something,
so that when you do it, it is not all mixed up. – A.A. Milne

The United States Congress passed the Homeland Security Act of 2002 as a direct and immediate response to the terrorist plane attacks on September 11, 2001 that killed almost 3,000 people in three coordinated attacks on the World Trade Center, Pentagon, and an in-air flight that crashed in a Pennsylvania field (Glazier, 2008). The Act created the Department of Homeland Security, a massive organization composed of 22 previously disparate agencies that was charged with oversight of domestic terrorism defense and coordination of a cohesive network of disaster response capabilities. The Federal Emergency Management Agency (FEMA) became one of the 22 absorbed into the Department of Homeland Security (DHS), reflecting a commitment to coordinate national emergency management efforts that was reflected in the publication of the National Response Plan in 2004 and a companion guidance document, the National Incident Management System (NIMS). That plan became the foundational document for the more expansive National Response Framework in place today. NIMS was designed to provide a common operating approach to incident management and encourage collaboration and cooperation among governments, departments, and agencies but a fundamental power struggle rendered the framework ineffective and the hurricane response a fiasco. In response to the failure of the National Incident Management System (NIMS) during Hurricane Katrina, there have been calls for more centralized disaster response in the federal government (Lester & Krejci, 2007).

After 9/11, budgets for defense-related agencies sky-rocketed: Homeland Security's discretionary budget jumped from about $16 billion in 2002 to more than $43 billion in 2011. Coast Guard, Transportation Security Administration and Border Patrol have also more than doubled since 2001 (DHS, 2012). Despite these increasing funding commitments, national efforts to coordinate emergency planning, preparedness and response efforts were still suffering from significant failures of governance (Senate Report, 2006; House Report, 2006).

These failures were epically demonstrated during the response to Hurricane Katrina, four years after 9/11. Hurricane Katrina made landfall in New Orleans, LA at class 5 strength, impacting 90,000 square miles and leaving over 1,800 people dead (National Oceanic and Atmospheric Administration, 2010; National Research Council, 2007). Damage estimates from Hurricane Katrina top $80 billion with a total economic impact assessed at more than $150 billion (National Research Council, 2007). After action analyses of the event revealed that every level of government demonstrated inadequate institutional capacity to manage the response. Specifically, the newly structured DHS was untested and uncertain about how to deploy its authority and resources. Key functions, political influence, and resources of the Federal Emergency Management Agency (FEMA) had weakened under the leadership of Bush administration political appointees (Moynihan, 2009).

Hurricane Katrina was a storm of massive proportion with devastating impacts to show for it. Any improvement actions determined to increase response capacity and decrease community vulnerability to events the size of Katrina will surely be robust enough to contain the vast majority of disaster events, as the most will be much less devastating in scope and scale. Research suggests that action based on traditional leadership tools like silo/centralized command and control, resource allocation and funding distribution do not adequately support post-disaster community resiliency and recovery (Gopalakrishnan & Okada, 2007). In fact, traditional leadership tools may not be best suited to guide action to reduce the risks or improve vulnerability in the mitigation or preparedness phases of the emergency cycle, either. This work may be better accomplished by teams who can engage in rapid reflection to make sense of a fundamentally reordered landscape, and who can seek new approaches rather than learned responses that do not fit (Lagadec, 2008). These teams, as a collective set of crisis responders, should be considered as a network, with varying degrees of connectivity (Moynihan, 2008).

Need for the Study

Alexander suggests that vulnerability is a greater disaster risk than hazards themselves (2006). Although reduction of vulnerability is a human rights issue, risk reduction, which is essentially a conversation of economic impact, is not (Sarewitz, Pielke, & Keykhah, 2003). Despite the debate around risk and vulnerability and the absence of common set of definitions and methods to collect human impact data, the importance of reducing both risk and vulnerability is widely acknowledged (Guha-Sapir & Horois, 2012). In 1953, the U.S spent approximately $0.13 per person on disasters ($20.9 million adjusted to 2009 dollars). This spending has increased steadily to $4.75 per person in 2009, or $1.4 billion, with many more disaster declarations (National Academies, 2012).

The key to reducing community disaster vulnerability and building resilient communities is the development of participatory networks that facilitate trust and exchange. Shared goals and common experiences engender a sense of trust between individuals and organizations. Increased trust encourages resource and information exchange. This exchange builds resilience throughout the community as relationships develop and adaptive capacities are shared, increasing the speed, redundancy, robustness, and resourcefulness of the network as a whole (Bruneau et al, 2003).

According to Kapucu, building trust among public, private, and nonprofit organizations can best be done prior to emergency situations (2006). The stronger a local government’s pre-disaster relationships with other local governments, public entities, non-profit organizations and businesses, the better prepared it will be to mobilize help and mutual aid when necessary (Smith & Reiss, 2006). Increased trust facilitates resource and information exchange and the flow of influence (Lin, 1999). More resilient communities use aid more efficiently and effectively after disaster, increasing the likelihood of sustainable recovery to pre-disaster function and decreasing the economic and intangible costs associated with disaster recovery.

In recognition of the need for alternative strategies, the US Department of Homeland Security requested that the National Research Council form an ad hoc committee to organize a two day workshop to discuss the use of social network analysis as a tool to build community disaster resilience (Magosino, 2009). This committee planned a workshop to investigate how social network analysis could be useful across all phases of the disaster cycle (mitigation, preparedness, response, recovery). The workshop invited attendance from experts in resilience science and SNA and practitioners in emergency management to discuss how SNA, as a governance tool, could be used to increase community resiliency. The workshop summary called for innovative research into how social network analysis can be used to build community disaster resilience. In response to expert opinion expressed in the workshop acknowledging the necessity of reliable baseline data, this research attempts to measure network integrity and resilience and explore factors that may influence it.

Just as it took almost 350 years for the modern calendar to be accepted around the world after it was introduced by Pope Gregory XIII in 1582, translating even expert research into practice can be a drawn out process. According to Stevens, it can take 17 years to turn 14% of research to the benefit of patient care (2004). As the Department of Homeland Security found when it was challenged to respond to Hurricane Katrina in its organizational infancy, disaster does not wait for convenience. With these trends, is important to invest in research that can generate protective action early and consistently regardless of a disaster's schedule.

In addition, evaluation of the relationships between disaster history and emergency management network resilience and between network resilience and community well-being may provide a better understanding of how exchange and trust within state emergency management networks can be intentionally developed to improve network resilience and by association, community resilience. The more resilient a community, the less vulnerable its residents and infrastructure are to disaster impact and the fewer the resources required to recover and rebuild.

Significance

Significance of the Problem

In 2005, the US Congress reported that an investment of one dollar in hazard mitigation (disaster preparedness) provides the nation with four dollars in future benefits (Woodworth, 2006). If the federal government invested just 1% ($210 million) of the more than $21 billion spent on disaster relief in 2011 on preparedness, $840 million in benefits could have been realized from just that one year alone. With over 1,000 major and emergency presidential disaster declarations between 1995-2010, the economics of this alternative investment equation becomes almost boggling, especially given that there is a scarcity of research on alternative emergency management mitigation and planning/ preparedness strategies.

Local community network development would be an ideal strategy to pursue as the majority of disasters have the heaviest impact at the local level, where communities may be 'on their own' for the first seventy-two hours after disaster impact (O'Leary, 2004). Unfortunately, limited resources and experience often mean the weakest coordination and response capacities are also often found at the local community level. In communities where residents do not have a strong capacity to protect and manage their own life safety and property, the impact of responding to and recovering from is increased. Without better data to support best practices for network development, however, it is economically and strategically unfeasible to focus network building strategies at local levels given the unpredictable nature and frequency of disaster and emergency events. With fiscal and resource constraints at the local level and the difficult challenge of building networks of effective action in dynamic environments like emergency response (Kapucu, 2005), networks that self-organize to improve network integrity have the potential to do far more to bolster sustainable recovery than any amount of disaster aid applied only at response and recovery stages. This study reasons that the state government level of emergency management could be the most appropriate sector for network development because it can maximize penetration and sustainability of preparedness activities throughout local communities.

Scope of Study

The objective of this cross sectional factor analysis study was to contribute to the baseline knowledge about the characteristics that influence state emergency management network resilience as perceived by the management staff. This research surveyed state emergency management network employees in 47 U.S. states regarding their perceptions of their state network integrity, community resilience, and state emergency management network resilience and examined other data sources to measure state ecological variables of disaster experience, state well-being, population, emergency management budget, number of full time state emergency management employees, FEMA region that may influence the development of network resilience in each state.

The primary goal of this study was to develop a model that explores the influence of individual and state level variables on the resilience of state emergency management networks. If those variables can be identified, they can be assessed within and across states to build stronger, more efficient and effective networks that have an increased capacity to reduce the impact of disaster on their state community.

The primary expected benefit of this research is generation of foundational insight into constructs that measure the emerging concept of emergency management network resilience and predictors of state emergency management network resilience. Historically, experts have only been able to extrapolate this information from expensive after-event experience. A better understanding of desirable network characteristics would allow all states to more efficiently focus emergency management network development efforts to build partnerships that strengthen the network without having to experience the emergencies that historically forge them.

While measurement of the actual number and quality of exchanges among organizations within each state network and/or a network analysis for each state networks would be a direct way to validate this assumption, both are beyond the scope of this research and not indicated until a better basic understanding of state emergency network resilience is obtained.

Chapter Two reviews the relevant literature. It outlines a brief history of federal disaster response strategy and disaster history in the United States. It also discusses the concepts of vulnerability and resilience in disaster before exploring the development of networks as an organizational system. Next, complex adaptive systems theory is offered as a complimentary perspective to guide development for networks of disaster entities. Study aims, hypotheses and a structural model are presented.

Chapter Three presents the methodology applied in this study. The research design, hypotheses, measurement model and structural models are introduced. Data sources, collection and analysis are then discussed.

Chapter Four presents the results of the study in 3 sections. The first section, exploratory analysis, includes descriptive statistics about the sample at both the individual level and the state level. The second section includes discussion of qualitative responses to the researcher developed survey tool followed by correlation analysis. The third section, confirmatory analysis, summarizes both measurement model and structural model results.

Chapter Five presents a summary of the study and considers implications, contributions, limitations, and conclusions. Implications are addressed from theoretical, methodological, practical and policy perspectives. Contributions at different levels are discussed. Finally, conclusions are presented with recommendations for future research.

CHAPTER TWO: LITERATURE REVIEW

Intensifying impacts of environmental and technological disasters across the world are sobering (Reser & Morrissey, 2008). As the human population continues to increase and migration toward hazard prone areas like coastlines continues, the social and economic cost of natural disasters will continue toward catastrophic levels (Peek & Mileti, 2002). Between 1999 and 2009, more than 25 million people were affected by disasters with over 5,400 disaster related deaths reported in the United States alone (Red Cross, 2009). In 2010, the world saw a collective economic impact of over $123 billion, climbing above the 10 year average of $98 billion (Guha-Sapir, Vos, Below & Ponserre, 2010). Intentional efforts to design emergency management systems to reduce the impact of disasters requires an understanding of what factors influence that impact, which of those factors can be influenced and more importantly, how to influence them. While the scale of disaster impact is heavily aggravated by vulnerability and mitigated by resilience, economic and social science literature agree that outcomes can be impacted by both perception and reality of risk including damage to health, quality of life, property, services and systems (O'Riordan,1995; Slovic,1997). Toya & Skidmore suggest there is an underlying social/economic fabric that can improve the level of safety during disaster (2005). Organizational theory research has presented strong support for the premise that organizations, working together, can build the capacity of a community to identify and respond to its needs beyond those working alone or in competition (Provan et al., 2004).

The ability of networks to act as a fabric, specifically state emergency management networks, to mitigate community vulnerability and strengthen community resilience, is explored in this study. This research is designed to explore the impact one governance tool, networking, could have on building trust and exchange – two precursors of increased community resilience, a protective factor that inhibits indirect damage. Theoretical foundations of vulnerability and resilience science are presented to outline the perspective of this research.

Impacts of Disasters

The top 10 most expensive natural disasters between 1980 and 2010 caused over $500 billion in damage and over 22,000 deaths (Information Institute, 2013). In 2011, the economic impact of disaster was estimated at more than $55 billion (National Academies, 2012). While exact figures are impossible to confirm, disasters are costly events no matter the cause. Losses are usually underreported because they can be very difficult to identify in the immediate aftermath or measure consistently throughout recovery. These staggering numbers drive research like this study to better understand ways to minimize those losses, some of which are never recovered.

Kousky suggests the economic costs of (natural) disaster could be considered in two categories, direct damages and indirect damages (2012). Direct damage, the destruction done to buildings and contents, is the easiest to grasp visually. While quantification of these damages can present theoretical challenges around assessed vs. replacement value and can be complicated by insurance and government aid payments, there is often an established cost basis to guide assessment. Indirect damages are far more difficult to capture because they do not need to be tied to direct observed physical damage (Kousky, 2012). An example of an indirect damage by her definition might be business interruption attributed to electricity loss due to an event that was unrelated to her building. Other indirect damage costs could include a decline in quality of life related utility, costly compensation for disaster related issues like longer travel times due to road closures or the expense of purchasing battery operated lighting in response to power loss.

As difficult as determining direct costs of a disaster can be, accurate estimation of indirect costs can be exponentially harder to identify through empirical analysis (Okuyama, 2008). Indirect effects are hard to verify, difficult to model, can flux in response to the size, scope, and geography of the event, and depend on the resilience of the economy and pace of recovery (Rose, 2004). Another significant challenge to confident cost measurement is identification of the number of response organizations involved in an event. What is not elusive, however, is awareness that the cost of disasters is increasingly overwhelming both in terms of economic and societal impact. Cost containment can't be done without better information and resource management, something emergency management researchers and professionals are working toward every time they navigate the emergency management cycle.

History of Emergency Management in the US

Emergency management efforts are divided into four distinct cycle segments by FEMA: prevention, mitigation, protection, planning/preparedness, response, and recovery, although activity during the *response* and ensuing *recovery* phases are usually the most dramatic visible (see Figure 1).

Figure 1. Emergency Management Cycle

The preparedness segment includes activities to make ready for hazards that cannot be prevented, or mitigated. The response segment includes those activities that are undertaken to respond to emergencies when they occur. Activities in the recovery segment reflect work to restore the community to its pre-emergency condition. The mitigation segment includes those activities that decrease risk by reducing or eliminating the potential for damage and disruption from future disasters. This cycle is commonly described as "comprehensive emergency planning or management" (CEP or CEM) and, while primarily coordinated by local public agencies, works best when a broad range of private actors are included in planning and relief efforts (Gazley & Brudney, 2007).

Direct effort to coordinate federal resources during an emergency began when President Truman signed the Federal Civil Defense Act of 1950, authorizing creation the Federal Civil Defense Agency in the Office of Emergency Management. Early work of the FDCA attempted to create a national plan for fallout sheltering but evolved to address evacuation as a strategic priority when confusion over agency goals led to budget constraint by Congress (Blanchard, 1987). President Eisenhower merged the FDCA with the existing Office of Defense Mobilization in 1958 only to see President Kennedy transfer the civil defense functions of the newly conjoined Office of Civil and Defense Mobilization to the Secretary of Defense in 1961. The remaining functions were performed by the newly designated Office of Emergency Planning, which was renamed the Office of Emergency Preparedness in in 1968. Job functions and responsibilities were then transferred to the Departments of the Treasury and Housing and Urban Development, and to the General Services Administration when the Office of Emergency Planning was terminated in 1973 (US Government manual, 1995).

In an effort to organize disjointed plans across multiple agencies, President Carter created the Federal Emergency Management Agency (FEMA) in 1979 to consolidate federal disaster related responsibilities (FEMA, 2010). Leading FEMA continued to absorb responsibilities from its predecessor agencies and from new directives even after its 2003 integration into the newly created Department of Homeland Security with 21 other government agencies, where it was housed within the Directorate of Preparedness and Response. As agency organizational charts evolved, so did planning and response priorities and doctrine. FEMA led development of the National Response Framework (NRF) in 2008 to replace both the 2004 National Response Plan and its predecessor, the Federal Response Plan of 1992. The NRF describes principles, roles and responsibilities, specific authorities and best practices to guide incident management from serious local events to large scale national disasters (FEMA, 2013).

When local, regional and state capacity to respond to an emergency event is exceeded, federal resources are coordinated according to the National Response Framework. Emergency managers at all levels of preparedness and response refer to the tenets of the National Response Framework because they provide a scalable structure to assess, plan, and deliver essential capabilities during an emergency response like mass care, operational coordination, and transportation.

Jurisdictional distinction between emergency management agencies and resources is usually made between federal, state, and local levels. FEMA region is an important additional level to consider in emergency management. FEMA's mission is 'to support our citizens and first responders to ensure that as a nation we work together to build, sustain and improve our capability to prepare for, protect against, respond to, recover from and mitigate all hazards' FEMA, 2012). In an attempt to carry out that mission, FEMA has created 10 geographic regions of service across the United States, each with a regional office of technical experts available to support planning, training and exercising efforts of emergency management partners in their region. This support is delivered in accordance with three principles of Whole Community FEMA identified with stakeholders to move their strategic work away from a government centric model and into larger collective emergency management teams, or networks. The principles are understand and meet the actual needs of the whole community, engage and empower all parts of the community, and strengthen what works well in communities on a daily basis. A map of FEMA regions is illustrated in Appendix A.

While FEMA's regions encourage standard dissemination of federal policies, states within the regions can have very different organizational structures for day-to-day operations of their emergency management agencies. State agency structures vary within geographical and FEMA regions and can change from year to year, especially when a new state governor takes office. In 2010, the state emergency management agency was located within the Governor's office in 9 states and within the Department of Public Safety in 14 states. In 18 states it sits within the military department under the direction of the adjutant general. In the remaining 11 states the agency is located in a combined emergency management/homeland security agency (NEMA, 2010).

Regardless of the sponsoring agency, all states have developed working partnerships, or Emergency Management Assistance Compacts, that outline their commitments to provide support to each other in advance of a Federal Emergency Management Agency (FEMA) response (Kapucu, 2009). This assistance offers provisions for states to share any capability or resource they can and ensures a consistent framework to manage reimbursement, liability, and workers compensation across states. While EMACs are agreements between state entities, most state emergency management agencies have Memoranda of Understandings (MOUs) with entities within their own networks that speak to similar assurances, albeit with widely varying degrees of complexity and success.

Regardless of jurisdictional levels (and often in spite of them), Smith and Reiss (2006) suggest the stronger a local government's pre-disaster relationships with other local governments, public entities, non-profit organizations and businesses, the better prepared it will be to mobilize help and mutual aid when necessary

While long a staple of emergency management response and recovery, vertical incident management frameworks like those that came before the NRF are no longer believed to be the best primary tools to facilitate resource coordination and exchange. Given that these frameworks have never been well applied to the mitigation and planning/preparedness phases of the emergency management cycle, reliance on conventional centralized chain of command is a thing of the past (Gopalakrishnan & Okada, 2007). Frameworks that instead support coordination of mitigation and preparedness efforts are essential to effective response and recovery. McEntire et al. (2002, p. 276) have suggested the need for a "paradigm shift" in emergency management research to put a greater focus on proactive efforts to identify and reduce community vulnerabilities, making them more resilient against the negative impacts of disasters and hazard events. In this study, respondents were surveyed about the length of time they have worked experience in emergency management and in their current agency in an attempt to measure any impact these sorts of shifts may have on perception of network resilience.

Theoretical Frameworks

Vulnerability and Resilience

Reducing the impact of disaster, economic and otherwise, is a critical challenge to protect societal well-being. There is general consensus about the importance of risk reduction in mitigating the vulnerability of human settlements to natural hazards (Guha-Sapir & Hoyois, 2012). Risk research has traditionally focused on strategies to make the economic impacts of disaster "less bad". Vulnerability research, on the other hand, accepts that impacts are affected by other social dimensions including class, ethnicity, community structure, community decision making processes and political issues (Yodmani, 2001). More tools exist to measure risk reduction than to mitigate vulnerability in the literature because risk is primarily treated as an economic measure of impact and as such is more confidently and consistently measured. Burton demonstrated a modest inverse relationship between deaths due to natural disasters and income for twenty countries in 1973 and 1986 (1993).

As vulnerability research has grown, the field has developed a more proactive understanding of vulnerability reduction as, in essence, another name for economic, infrastructure, and social development to inure communities to cope with any disruptive hazard activity (Paton, 2008). Vulnerability science suggests there are two main mechanisms by which vulnerability, or "potential for loss" (Cutter, 1996), can be mediated; exposure and sensitivity (Adger, 2006; Cutter, 1996; Cutter et al, 2008.)

The strongest models of vulnerability reduction address both risk of exposure and sensitivity. Cuny's 1983 work focused discussion of a developmental approach to reduce vulnerability in disasters in an effort to address the underlying causes of increasing social vulnerability like poverty, population, development and environmental degradation (Cutter, 1996). Dwyer et al builds on Birkmann's 2006 vulnerability reduction model by including consideration of resources in the following formula for assessing and preventing risk by reducing vulnerability: *Risk = Hazard * (Vulnerability – Resources)* where *Risk* is the probability of loss, *Hazard* is a circumstance or event with a chance of harm, *Vulnerability* is the extent to which persons or things are susceptible to being affected and *Resources* are those protective assets in place that will mitigate the negative impact of the hazard (cited in Flanagan, Gregory, Hallisey, Heitfgerd, & Lewis, 2011).

Cutter's Hazards of Place model of vulnerability combines biophysical vulnerability (physical characteristics of hazards and environment) and social vulnerability to determine an overall place vulnerability as a pre-event condition, independent of hazard type, but also considers post-event human adjustment (1996). The focus on place is an important aspect of the HOP model because it posits that variables that characterize place can be dynamic across space and time (Morath, 2010). For example, a place can be at increased risk of experiencing a hazard event due to geography, but the community that inhabits the topography can be less vulnerable if they are a strong, vibrant, connected society. Those connections imbue the community with resilience, a capacity to support themselves and each other in ways that decrease the negative impacts after disaster.

The concept of resilience originated in the field of ecology science, but has been explored across a wide diversity of hard and soft science fields including psychology, geography, nursing, engineering and systems science (Kulig, 2000; Klein et al., 2003; Manyena, 2006). In the engineering field, researchers at the Multidisciplinary Center for Earthquake Engineering Research (MCEER) at the University of Buffalo in New York identified a resilience framework with four properties of resilience for physical and organizational systems considered fundamental to reducing the likelihood of failures to critical infrastructure (thereby, reducing the impacts of failure) and speeding the time to recovery during disaster (Miles & Chang, 2006). Those four indicators, robustness, redundancy, resourcefulness and rapidity, were the foundation for the development of the Perception of Network Resilience Survey tool created for this study.

In the social sciences, resilience research grew as a result of a shift in psychological research from characteristics that contribute to failure to those that facilitate triumph (Norris, 2008; Polk, 1997). Essayist Brian G. Jett defines resiliency as "the art of learning to repeatedly refuse to do anything else other than rise again after any and all set-backs" (2004). Whether as art or science, resiliency has been studied as a composite of individual, familial, environmental and cultural factors as well as an arrangement of personal and social resources.

To date, resilience at the individual level has been most heavily explored in psychology, juvenile education and justice and social work therapy as character trait of coping and response to stressful life events in children, adolescents, adults, and families. Miller (2003) described traditional resiliency research as associated with the study of “at-risk” children or adolescents who have managed to succeed in life despite having to face serious life challenges.

With extensive study of over two million youth since 1989, the Search Institute has provided ample evidence that building the number of assets present in each individual will positively impact healthy development and growth and increase individual resilience. According to the Search Institute (2005), their model identifies 20 internal and 20 external developmental assets. Assets in the external category identify positive experiences communities can promote in their environments to increase individual adolescent resilience including support, clear boundaries and expectations, fairness and equity, and competence. While directed toward youth, community asset building activities like those encouraged by the Search Institute benefit whole communities by association.

Emerging research into the ability of a community to be resilient has demonstrated little consensus around models to date. The studies that do present models are primarily economic loss estimation models, and authors acknowledge the inadequacy of that dimension alone to capture the essence of resilience in communities (Chang & Shinozuka, 2004). It is probable that lack of consensus around valid models is partly due to the complexity of the concept but a challenge may well be due to the number of disparate disciplines studying resilience from the perspective of their own professional literature with little successful exploration of shared themes. The research community has long demonstrated disagreement about the definition of resilience, classification of resilience as an outcome or a process, typing resilience (as an economic, infrastructure, ecological, or community system), and which policy realm (counterterrorism; climate change; emergency management; long-term disaster recovery; environmental restoration) it should inform (Cutter, Burton & Emrich, 2010).

Many definitions of community resilience do, however, share the common theme of societal capacity to absorb negative impacts of adverse events and recover to a baseline (or better) function. Community disaster resilience is defined by Renschler et al (2010) as the ability of social units (like organizations and communities) to mitigate hazards, limit effects of disasters when they occur, and execute recovery activities in ways that lessen social disruption and abate the effects of future extreme events. Ben Nesher, Lahad, & Shacham define community resilience as a community's ability to "stand firm" against loss of life or damage (2002).

Kulig discussed community resiliency research by Mangham, McGrath, Reid, & Stewart that proposed adaptation of a similar type of risk and protective factor framework to the community level (2000). This work also presented lists of variables that positively and negatively impact a community, but was criticized for not addressing the dynamic nature of community and the changes communities can undergo during a collective reaction to stress like disaster or war.

Krovetz suggests that schools, however, are poor exemplars of resilient communities (1999). Most schools have too-large classes and a school day that is too hectic to allow meaningful interaction among students and staff. This combination prevents the setting of high expectations and ability to offer support and value the participation of each student. In contrast, Krovitz identifies "gangs" as very resilient communities. He defines gangs as everything from the common image of a group of delinquent thugs to the informal groups that attend synagogue or Boy Scouts together. In these units where students feel trusted, accepted, supported and respected, they demonstrate more resilient characteristics. Individual and collective capacity to triumph over shared adversities is rooted in maintaining and augmenting perceptions of being supported, of social cohesion and cooperation, and of a sense of belonging to a valued social group and community (Bonanno, Brewin, Kaniasty & La Greca, (2010).

In nursing, community resilience was initially developed to clarify the role and definition of community beyond that of geographic groups of people or groups of groups in the environment domain of nursing theory (Kulig, 2000). While Kulig's initial developmental work was primarily done with a rural Appalachian community that recovered from both economic and natural disaster, further expansion of the concept has expanded the scope of her model. The three current components of Kulig's Community Resiliency Model are 1) interactions are experienced as a collective unit, 2) expression of a sense of community, and 3) community action (2000).

According to Kulig, the first component includes evidence of getting along, a sense of belonging, and networks (2000). The second component derives from the first, and includes a sense of community, both in mentality and outlook (hope, spirit). The third component is a combination of the first two into a community cohesiveness that is necessary for collective action, specifically that action of coping, problem solving, and recovery.

Regardless of the whether models measure the concept of disaster resilience at the micro (individual, family), macro (community, systems), or everything-in-between level, most are roughly comprised of two shared features: 1) the ability to resist and absorb disturbances and 2) the ability to reorganize and recover reasonably quickly (retain the same basic structure and return to the same functional level) (Mayunga, 2009). These commonalities and those elements of resilience already addressed informed the development of the Perception of Network Resilience Survey tool created for this study to measure 5 characteristics of the construct of network resilience. See Table 1.

Table 1. Five Characteristics of the Construct of Network Resilience

***Robustness**	Strength or ability of elements or systems {the network}….to withstand a given level of stress or demand without suffering degradation or loss of function.
***Resourcefulness**	Capacity of the element [or] system {the network} to identify problems, establish priorities, and mobilize and exchange resources when conditions exist that threaten to disrupt some element [or] system {the network}.
***Redundancy**	Extent to which elements [or] systems {of the network} exist that are substitutable.
***Rapidity**	Capacity {of the network} to meet priorities and achieve goals in a timely manner in order to contain losses and avoid future disruption.
Relationships	Strength of connectivity between {network} entities

*included in MCEER's 4Rs - Dimensions of Resilience (Univ. of Buffalo)

Understanding the relative role of network characteristics in performance can help networks recognize their own strengths and more critically evaluate how the network structure influences the resource and information exchanges network members have within the network. Informed network development can help develop and protect strategic relationships that allow members to remain viable, protect their missions and respond to community needs during times of stress.

The diversity of the literature base around models of community resilience is surpassed only by the consistency of themes in community resilience models of support, trust, unity, and inclusion as important indicators of resilience for both individuals and communities. Resilience theories have consistently found that relationships with high levels of trust and exchange are considered protective during harmful experiences for both individuals and groups. Given the emphasis in community resilience theory on relationships built on trust and exchange, community resilience is presented as a predictor of network resilience in this study.

Network Theory

Just as John Donne wrote "No man is an island…", modern interpretation would suggest that "No man is a network". Although over 400 years have passed since the poet penned his *Meditation XVII*, the truth is that no one person can stand alone against all hardship and adversity that life can bring and expect to survive it. In fact, the formation of cooperative partnerships or networks is one of the oldest and most commonly considered strategies for addressing collective human (community) need (Provan, Veazie, Staten, & Teufel-Shone, 2004). Network theory guides analysis of the interactions and resources embedded within and available through relationships between network members. In this study, it guided development of the Network

Resilience Scale to measure the network characteristics of rapidity, redundancy, relationships, resourcefulness and robustness as indictors of a resilient network.

A nontraditional tool, networking joins the ranks of local self-organization, community training, and communication technology as a mechanism of indirect governance practice. Podolny and Page defined a network as a set of entities that “pursue repeated, enduring exchange relations with one another”(1998). In the public administration field, networks are considered to belong to one of three taxonomies. The first, policy networks, are identified as those networks with a primary function of collaborative or distributive decision making about resource allocation. The second, collaborative networks, are identified as those networks focused on shared production or provision of public services. The final type, governance networks, are focused on working toward common goals, often integrating collaborative service delivery and collective policy making (Kapucu, 2015). For the purpose of this research, state emergency management networks are treated as governance networks although each state network may reflect a different ratio of collaborative delivery to collective policy making based on culture, legislative authorities, and organizational structure.

Networks have the potential to enhance community resiliency and boost sustainable disaster recovery because they reflect a structure designed to facilitate exchange of information and/or resources, which stimulates trust. This trust is an intangible asset that acts as a proxy pipeline for information flow, mutual aid and collective action - a concept identified as social capital by Robert Putnam (2000). Much of the exchange that occurs within networks is a result of communication pathways. In formal networks like those that represent interorganizational relationships communication pathways are clearly delineated and are often represented by straight lines and predictable patterns based on shared goals or resources. More informal networks, like social networks, demonstrate communication channels that more closely resemble wandering cow paths. These channels develop along less predictable lines based on shared interests and experiences.

Social capital is a necessary antecedent for community resiliency because it signifies that communities are connected in such a way that individuals and groups that consider themselves members of that community trust each other enough to reach out in support of each other. That support expedites sharing of resources and information and functions as a protective factor against vulnerability during a disaster and for sustainable recovery afterwards. This research hypothesizes that networks of emergency management entities share some basic characteristics to facilitate that exchange to build trust. Those basic characteristics are conceptualized as the construct of network integrity in this study. The three elements of that construct include degree of network insulation from the community it serves, fairness and equity of distribution of economic and policy decision making power, and readiness to respond collaboratively to an emergency. These elements were identified by the researcher as indicators of network capacity to adapt as a system.

To understand how networks develop, it is important to understand what they are. Networks can be defined as groups of entities (computers, people, and organizations) that participate in a relational exchange – usually of information or resources. The frequency and quality of that exchange can be influenced by the type of relationship the entities, also known as nodes in network theory, share with each other and the types of relationships between other entities in the network. Early development of network analysis theory viewed organizations in society as a system of objects joined by a variety of relationships (Tichy, Tushman, and Fombrun, 1979). Two decades later, Bazzioli et al were able to do a similar but more specific classification of approximately 70% of hospital-led health networks and 90% of hospital led health systems into well-defined organizational clusters in three parallel strategic/structural dimensions based on their analysis of entity relationships across systems (1999). Both Tichy et al's model and Bazzioli's classification demonstrate early evidence of the themes of rapidity, redundancy, reliability, relationships and robustness in network analysis theory. See Table 2.

Table 2. Dimensions of Desirable Network Assets

Tichy, Tushman, & Fombrun (1979)	**Bazzioli et al (1999)**	**Network Resilience Index**
1) Transactional content (**exchange** by social relationship) 4 types include: exchange of information, exchange of affect (liking, friendship), exchange of influence or power, and exchange of goods or services.	1) **Differentiation** - the number of different products/services along a continuum	Rapidity Redundancy
2) Nature of the Links: (Strength and qualitative nature of relationship between social objects) These links can be characterized by intensity, **reciprocity,** clarity of expectations, and **multiplexity.**	2) **Integration** – efforts used to achieve **coordination/**unity across organizational components	Resourcefulness Relationships
3) Structural Characteristics: the overall **pattern of relationships** between the systems actors. Four levels include: external network, total internal network, clusters within the network, and individuals as special (social) nodes within the network.	3) Centralization – extent that activities and/or management are **distributed** across the network	Robustness

The Community of Practice model is another network development strategy focused on identifying and enhancing information exchange in networks (Anderson, Hennessy, Cornes & Manthorpe, 2013). This network model creates a structure to facilitate access to peer support for health providers who care for patients with complex needs in order to mediate the providers' feelings of role or service isolation and to sustain motivation, an essential element of network sustainability. This model informed the objective definition of network integrity as an antecedent in this study.

Once relationships and exchange were seen as common themes in network structure, researchers began to explore how best to measure and quantify elements of those themes. Network analysis evolved as a mapping strategy that allows us to see how an agent is embedded within a system and how the structure of the system emerges by quantifying the number, scale and scope of relationships between network entities. Three types of centrality measures are commonly used to illustrate the significance of an entity's network position (Kar & Hatmaker, 2008). Kapucu describes degree centrality as the estimate of an entity's importance within the network in terms of their number of ties to other agents (2006). Hanneman describes betweeness centrality as the measure of the position of one network entity in relation to others, a good indicator of capacity to trade information or resources (Kapucu, Yuldashev, & Feldheim, 2011). Finally, Krebs described closeness centrality as the measure of how close an entity is to other entities in the network based on shortest distance between connections (2004). According to Krebs, betweenness measures the *control* a node has over how exchange flows in the network (how often is this node/entity on the path between other nodes?) while closeness measures how easily a node/entity can *access* what is available via the network (how quickly can this node reach all others in the network?) (2004). A network position where one node has easy access to others while controlling the access of other nodes in the network reveals high informal power, an important element of robust collaboration. Krebs and Holley describe a few considerations that network analysis can shed light on to answer these questions and strengthen economic and organizational performance (2002):

- Are the right connections (arcs) in place? Are any key connections missing?

- Who is playing leadership roles in the community? Who is not, but should be?
- Who are the experts in process, planning and practice?
- Who are the mentors that others seek out for advice?
- Who are the innovators? Are ideas shared and acted upon?

These measures of centrality informed the importance of including the characteristic of relationships in the measurement model for network resilience in this study.

Kapucu builds on Scott's measurement of networks by suggesting that in addition to looking at the ties or relations evaluated for selected entities, it is important to also evaluate how connected they are to one another, or the strength of the connection (2005). Assessing network relationships for both centrality and density can reflect patterns of trust, exchange, communication, and coordination among disaster response actors, all essential components of a network that can respond rapidly to changing needs for information and resource exchange. A network with many short connections between agents reflects a potential for robust, flexible, rapid response to stimuli because the potential for "noise" across communication and coordination exchange paths is smaller than that for those agents with relationships across great lengths (Kapucu, 2005). In disaster, that speed and responsiveness is critical to move information and resources efficiently and effectively in an environment of uncertainty that characterizes the early hours of any response.

Network research has consistently demonstrated that most networks can be resilient to the loss of random entities, but will lose integrity if a hub entity that is both centrally and strongly connected is lost (Scott, 2012). Kapucu, Arslan, & Collins encourage an additional dimension of network evaluation, clique analysis, to hone understanding of the way small intimately connected groups with shared patterns of interaction can impede or improve resource and information exchange during disaster (2010). Awareness of the presence of cliques is important to direct observation of network exchange for evidence of obstruction.

In networks where resource exchange patterns are established and stable, it certainly seems sensible that removing an integral entity would disrupt that exchange so network development efforts should be directed at maintaining the strength and primacy of those strong entities. Onnela et al, however, found that communication exchange flowed best through intermediate or weakly linked relationships (2007). Emergency management entities rely heavily on their network to support communication exchange during emergencies, so it is important to develop both intermediate and weak ties to maintain network integrity to support that need. In this study, respondents are surveyed regarding their perceptions of three indicators of network integrity that reflect the importance of strong, intermediate and weak ties; the fairness and equity of the distribution of decision making power across the network, the degree of insulation between their network and community, and the level of network preparedness to collaborate in an emergency. In their work on resilience and characteristics of the network that emerged in response to the World Trade Center attack on 9-11, Tierney and Trainor suggest that the multi-organizational networks that emerge in response to disaster represent a form of organization that is distinct from other types of organizational arrangements (2003).

At first glance, software renditions of network analysis of relationships in non-disaster related networks reflect little more than colorful chaos.

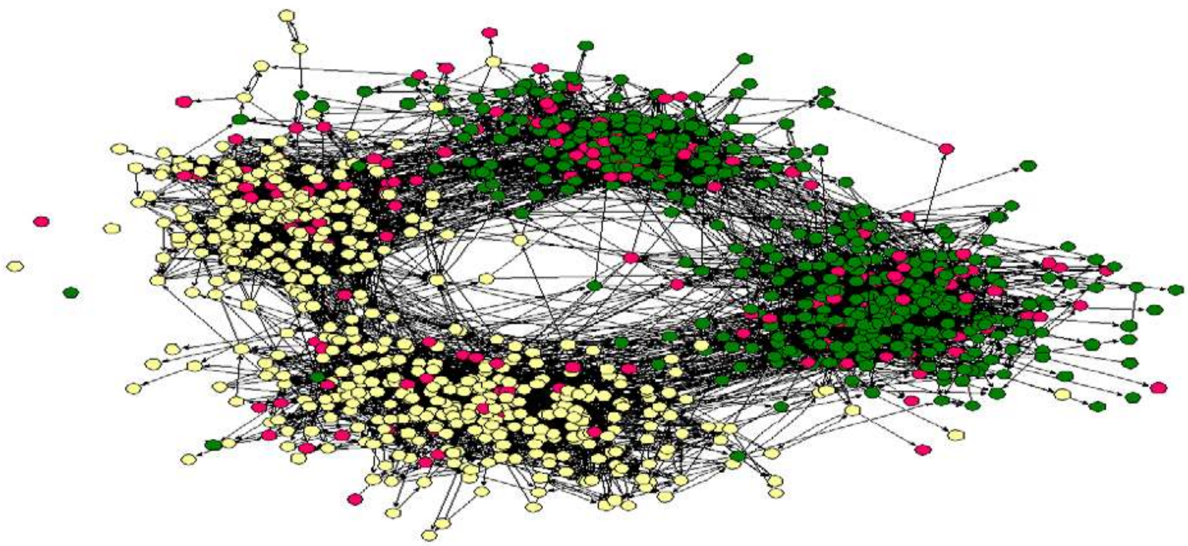


Figure 2. Network Analysis of High School Friendships (Moody, 2001)

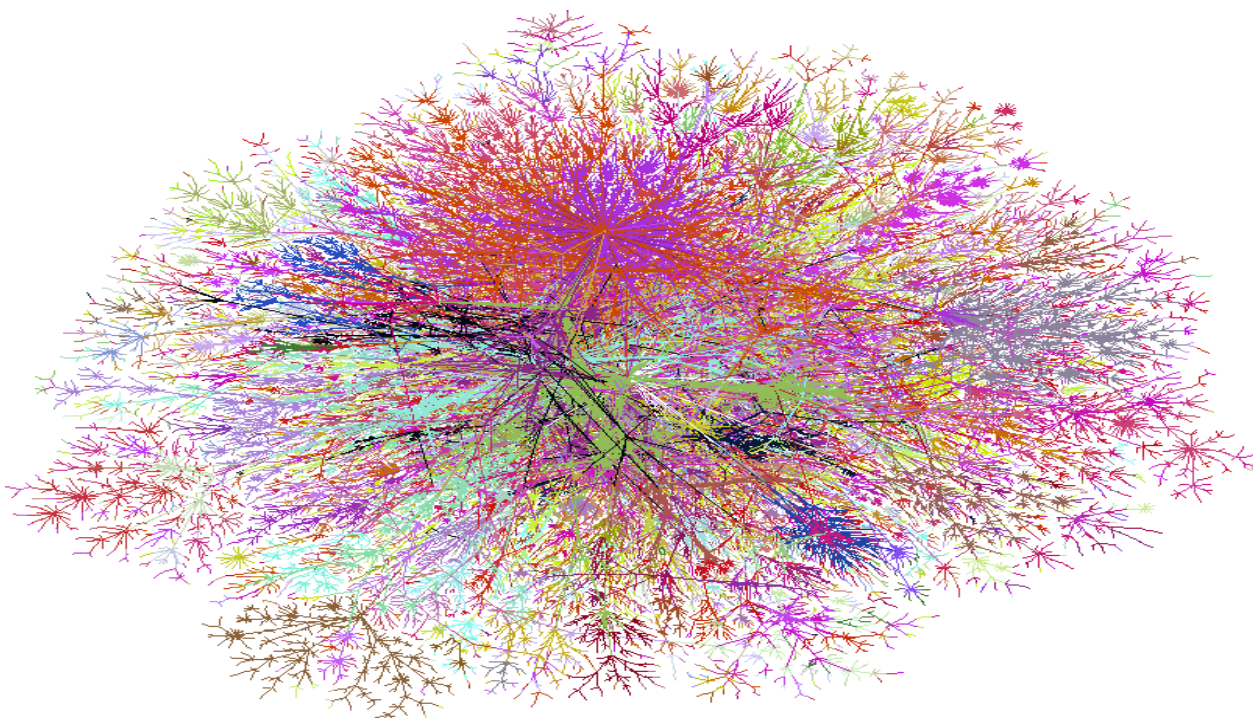


Figure 3. Network Analysis of the Internet (Cheswick, Burch, & Branigan, 2000)

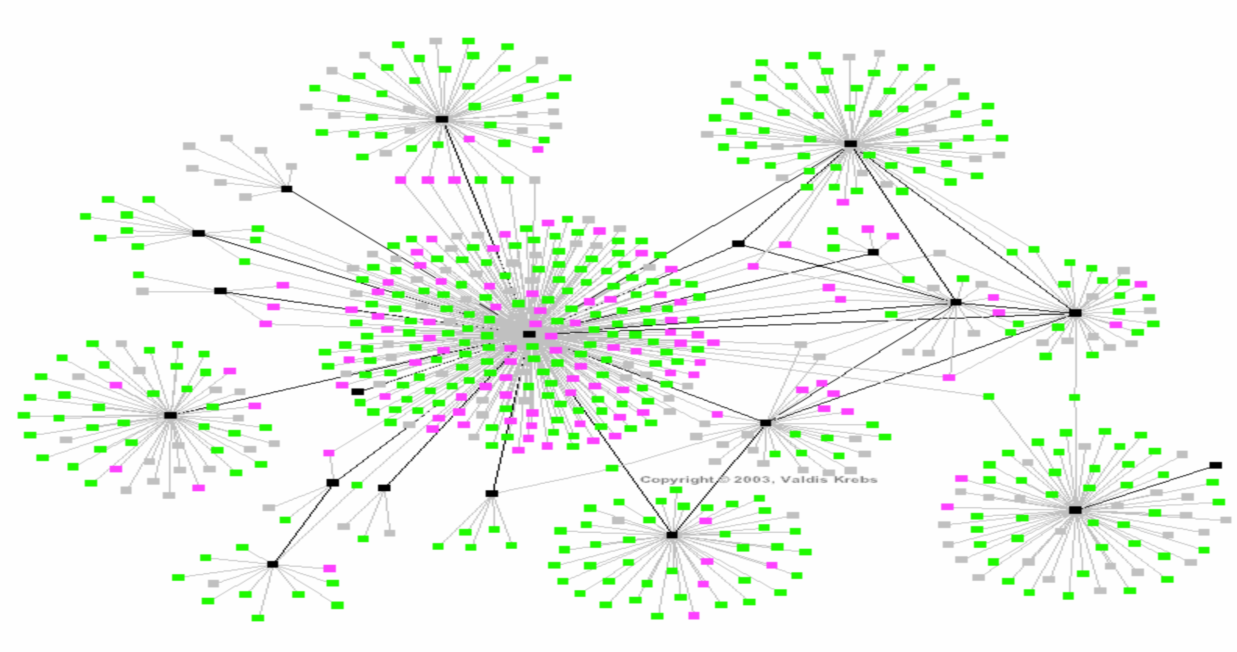


Figure 4. Network Analysis of Contagion of TB (Krebs, 2004)

In contrast, research into the actual network taxonomy demonstrates the opposite of chaos; in one significant study of health networks and systems, three strategic/structural dimensions including differentiation and centralization, which are measures of redundancy, were able to classify approximately 70% of hospital-led health networks and 90% of hospital led health systems into well-defined organizational clusters (Bazzoli et al, 1999).

Since disaster management can be viewed as a problem of material, personal, and information logistics, network models that address supply are highly relevant (Helbing, Ammoser & Kuhnert, 2006). Networks that can measure supply, demand, and impedance among their entities can then better model resource allocation (Walsh, Page, & Gesler, 1997). This modeling and resulting simulation analysis can help to identify patterns and connections of information, goods, and service flows among these actors to evaluate characteristics of resourcefulness and robustness.

While there are different purposes behind model development, according to Pritsker, gaining knowledge of these system interactions and interdependencies through modeling makes it possible to evaluate the impact of the operations of the components on the entire system. This impact then guides organizational response to system performance, as the best operating single component is secondary to the overall system performance (1997).

Unfortunately, there is limited data about which network characteristics are most important to improve state emergency management agency network resilience. It is important to understand how network entities interact so those elements of interaction that have the most impact on state emergency management agency capacity to develop and nurture organizational intentional alliances and relationships can be identified. Once these characteristics are identified, interventions can be developed to strengthen those that influence network resilience. In this study, comparison of network characteristics across sampled states could expand understanding of differences in those network characteristics and how they develop in relation to each other.

Once these characteristics are better understood, network analysis can further demonstrate how entities are embedded within systems and how the structure of those systems changes. When these differences are evaluated against measures of associated community social capital, correlations between network characteristics and community social capital may be explored. At points where the network comes into contact with community agents and actors to share information and resources, the community benefits from that increase in trust and shared common goals, thus experiencing an increase in social capital. Indicators of social capital can be considered reflective of protective factors, and an increase in those protective factors will raise the level of community resilience. With increased resilience, the community is better able to support and care for itself and its infrastructure, reducing vulnerability to future disaster.

Specific network characteristics may be associated with higher levels of community social capital, or society capacity, which can be seen as an inverse measure of vulnerability. If so, then disaster preparedness efforts can be more efficiently and effectively directed to reduce community vulnerability to the impacts of hazards by increasing community by funding specific types of network development activities that improve social capital.

As demonstrated in organizational performance literature, an over-constrained system will benefit from more freedom whereas an over-free system will require stability to optimize performance. In tumultuous environments, agents (organizations) rely on formal and informal relationships in order to work together to pursue shared goals and/or address common concerns (Kapucu, 2005). The nature of a state emergency response agency is that it has occasion to exist in both a ramp-up state of response and recovery to disaster and a stand-down state, when planning and preparation take precedent over the response and recovery phases. Historically, the dynamic nature of disaster has ensured that the ramp-up phase of disaster response relies more on informal relationships, as dependence on formal relationships is more unreliable given the changeable variety of actors that could be involved in any given type of disaster.

Fascinating analysis by Ford, Wells, and Bailey suggests that it is the voluntary nature of these network partnerships that makes them unstable (and thus vulnerable) because of the uncertainty regarding their partners' future behavior (2004). Their work suggests that without strong institutional or contractual authority to ensure cooperation, health care networks rely on the member partners to put the best interests of the alliance before their own individual needs. These authors suggest a non-cooperative perspective may better address network relationship issues like interdependence, vulnerability, mutual gain, transparency, and coordination while offering a more realistic structure to health care networks. In concert with network analysis, the authors applied game theory to the same network players to help explain strategic decisions by looking at current behaviors and probable outcomes. Taken together, these strategies can offer insight into participant's choices, plans, and actions. In contrast, Annen (2003) suggests that networks of exchange relationships are not so uncertain, and may in fact be valuable because they carry low enforcement costs because reputation is a valuable asset that motivates network members to cooperate.

For this study, networks were defined as those agencies and organizations that state emergency management employees considered to be involved in collective emergency management preparedness, planning, response or recovery within their state.

Complex Adaptive Systems

The geographic and temporal uncertainty of disasters is one of the biggest challenges to influence preparedness and response strategies around the world. In the United States, citizens expect the government to maintain a level of adaptive readiness that is difficult and expensive to sustain given the complexity of the many layers of governance and systems involved. It is exactly that complexity that invites consideration of complex adaptive theory as a guiding principle for this research.

Complex adaptive systems are complex because they are made up of multiple interconnected elements and adaptive because they have the capacity to change in response to stimuli and environments. All systems are situated in an environment that is always more complex than the system itself. This complexity prevents complete predictability with regard to the environment, but the system does depend on some regularity to maintain its infrastructure. It is the adaptive component of these complex systems that allows the system to draw down as much predictability as possible from the environment to organize and retain an efficient and effective system structure (Jost, 2003).

Although born from natural sciences like thermodynamics and biology, many concepts of complexity theory can be applied to social science. Morçöl suggests social systems are even more complex than natural systems because they include actions and relationships between entities (people) with complex biological and psychological systems and structures that evolve to accommodate those interactions (2015). Dahms suggests this adaptive capacity of an organization or social system in a complex and changing environment is, in fact, resilience (2010).

A complicated system can be understood in terms of its parts. If the whole of the system is different from the sum of its parts, then it is complex (Eoyang, 2004). By viewing the network that state emergency management agencies exist in as a complex adaptive system, it stands to reason that as the system adapts in response to disaster and peacetime environments, the most efficient and effective relationships of exchange and trust within the network are the most likely to survive. A flexible emergency response system that can effect structural adaptations can perform critical emergency tasks more rapidly and effectively (Comfort, 1999). As a complex adaptive system, state EM networks with more disaster related experience could be expected to demonstrate more structural adaptations. Those adaptations may be reflected in measures of network integrity and/or network resilience.

The Complex Systems Task Group of the National Academies Keck Futures Initiative identified robustness as a key indicator of that flexibility, or network adaptability (National Academies, 2009). Disasters cause significant disruption within networks, even those designed to respond to them. Different types of network topology respond differently to that agitation.

The Task Group suggests that the best network structure is a combination of *random*, where nodes are evenly distributed and/or interconnected and *scale-free*, where limited entities are highly interconnected and the majority of nodes have fewer connections (National Academies, 2009). This hybrid structure allows the network to adapt based on the threat details, in important outcome of a robust state.

In addition to the aforementioned influence of network theory, the Perception of Network Resilience survey was also informed by the key properties of complex adaptive systems introduced by Fryer. Selected elements are presented in Table 3.

Table 3. Crosswalk of Selected Elements of Fryer's CAS Theory and Network Resilience

Fryer's Property of a CAS	Definition	Network Resilience Index Construct
Emergence	The structure of the system develops from seemingly random patterns of behavior and exchange among and between agents within the system. These patterns influence the behavior of the agents and the structure.	Relationships
Requisite variety	The greater the variety in a system, the stronger it is. A system structured to require heterogeneity is stronger than one built on homogeneity in its agents.	Redundancy
Connectivity	The patterns of relationships and exchange among agents in a system are critical to identifying and understanding the strengths and weaknesses of the system.	Robustness
Self-Organizing	Vertical command and control hierarchy does not exist in a complex adaptive system. Constant re-evaluation and reorganizing replaces classical management via constant agent feedback and the emergence of new patterns of responsiveness.	Resourcefulness
Edge of Chaos	Systems exist on a continuum ranging from equilibrium to chaos. In a state of equilibrium, a system will lose the internal dynamics that allow it to maintain the ability to adapt to its environment, and it will die. At the other end of the spectrum, systems in chaos cease to function as a system, as functional patterns and reliable exchanges that provide internal structure have collapsed. The most productive position for a system is on the verge of chaos, where maximum variety encourages maximum creativity.	Rapidity

Good evaluation of a complex system involves pattern description, contextualization, and dynamic evolution (Eoyang, 2004). This research treats each state emergency response network as a system that does adapt performance and structure based on evaluation of observed patterns of exchange. This evaluation is done consistently within networks after the response phase of an event as part of the standard practice of after-action analysis to generate improvement plans. Thus, disaster history is an appropriate predictor at the state level of network resilience. in an effort to develop a model that illustrates what, if any, impact disaster history has on patterns of network characteristics can improve performance of that system.

Study Aims and Hypotheses

The goal of this cross sectional factor analysis research study was to better understand the attributes of individual and state-level formal and informal relationships that contribute to resilience among state emergency management networks. Networks, as adaptive complex systems, have the capacity to mobilize collective memory of experiences to develop horizontal and vertical collaboration to govern resource management (Norberg, Wilson, Walker & Ostrom, 2008). This capacity, when applied to awareness of the types of relationships that increase network resilience, could allow network actors to more efficiently prioritize activities that build trust and exchange within the network to increase network resilience. The following aims and hypotheses were identified for this study:

- Aim 1: To determine if network resilience is validly measured by the constructs of redundancy, rapidity, resourcefulness, robustness and relationships.
    - Hypothesis 1: Network resilience can be validly measured by the constructs of redundancy, rapidity, resourcefulness, robustness, and relationships.

- Aim 2: To determine if specific individual level indicators can predict perception of emergency management network resilience.
    - Hypothesis 2: Specific individual level indicators can predict perception of emergency management network resilience.
- Aim 3: To determine if specific state level indicators can predict perception of state emergency management network resilience.
    - Hypothesis 3: Specific state level indicators can predict perception of emergency management network resilience.
- Aim 4: To determine if state level variables are more influential than individual-level variables in explaining the variability in perceived emergency network resilience.
    - Hypothesis 4: State level variables are more influential than individual level variables in explaining the variability in perceived emergency network resilience.

This research framework is developed from an integrated consideration of the definitions of network resilience and determinants of potential influences on network relationships of trust and exchange drawn from community resilience, network development and complex organizational adaptation theory. A conceptual model of the proposed indicators of network resilience is presented in Figure 5. Individual-level predictor variables include perception of the latent variable network integrity, perception of community resilience, length of time employed in the field of emergency management, length of time employed at current state emergency management agency, gender, and level of educational attainment. State-level predictor variables include disaster experience, well-being, emergency management budget, number of full-time emergency management agency employees, population, and FEMA region.

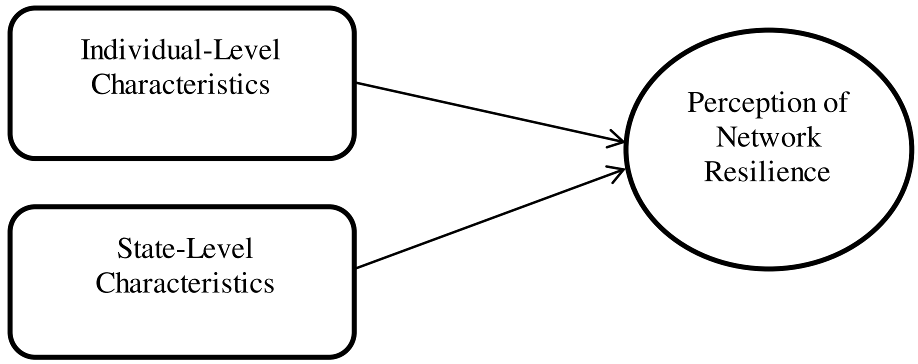


Figure 5. Conceptual Model of Network Resilience

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

Chapter Three presents the methodology applied in this study. The research design is introduced, followed by details about the study procedure and measurement of the study variables. Next, hypotheses, measurement models for network integrity and network resilience are proposed and structural models for individual and state level predictors of network resilience are presented. In summary, data sources, collection and analysis protocols are discussed.

Design

This study employed a two-level cross sectional analysis design. A minimum of 4 employees from the state emergency management agency each of the 50 United States and Washington D.C. were invited via email to complete a web-based 33 item survey about their personal perceptions of their state network's resilience. Participant survey responses provided the data for individual level predictors and indicators of network resilience in this study. Additional data from FEMA, the US Census, the American Human Development Index, the Social Vulnerability Index and National Emergency Management Agency member database informed state-level predictors of network resilience. This study tested relationships between emergency management network resilience and three categories of individual level variables (demographics, perception of network integrity and perception of community resilience) and three categories of state level variables (demographics, disaster experience, and well-being) with structural equation modeling.

Data Sources and Sample

Survey participants were identified from the 2010 NEMA State Emergency Management Agency Membership Directory. Published annually, this directory is created and maintained by the National Emergency Management Association (NEMA), a professional association of emergency management directors from all 50 states, the District of Columbia, and eight U.S. territories. Participants from the 8 U.S territories were not invited to participate in this research due to considerable variation in emergency management policy and practice between US states and territories. Sampling rosters were considered complete when four employees were identified for each state. The sampling plan for this study included 204 contacts, approximately 25% more than the minimum required to provide adequate power for analysis.

Individual level data was obtained from the researcher designed survey. Exogenous state-level variables were obtained from publicly available Federal Emergency Management Agency data, Measure of America Human Development Index data, Social Vulnerability Index data, and National Emergency Management Association membership data.

An IRB request for exemption from human subjects research was approved by the University of Central Florida's Office of Research (see Appendix J). The online survey tool required respondents to affirm consent to participate in order to begin the survey. See Appendix I for the informed consent letter. This research was conducted with a sample of state emergency management agency employees from all 50 states. As this research was not site-specific, there were no site-specific regulations or customs determined to affect this study.

There was no anticipated direct benefit of participation for individuals in this research. A goal of this research was to better understand strengths of state emergency management networks in order to facilitate development of those strengths without the extended trial and error associated with repeated real time natural disaster/emergency events. No direct personally identifiable data was collected. Some potentially unique demographic data was collected in the form of qualitative responses, but is not reported at the individual level in conjunction with any other information that could enable identification.

Procedures

The NEMA 2010 directory provided contact information for each State Emergency Management Director and up to 7 additional key staff for each state. For those states for which the NEMA database included fewer than four contacts, the researcher identified agency staff from other sources including official agency web pages and state staff directories. These additional staff were added to the sampling plan roster by way of a seniority stratification beginning with the Agency Director and followed by any Agency Deputy Directors, Agency Assistant Directors, Agency Planning Chiefs, and Agency Deputy Planning Chiefs. Participants were invited through their state agency email addresses to complete an anonymous web-based 33 item survey hosted by SurveyMonkey about their perceptions of the resilience and integrity of their current state emergency management network. (See survey questions in Appendix B). Online access to the survey was available for 6 weeks after 204 invitations were sent. Employees who received the initial invitation were encouraged to complete the survey and to forward the invitation to colleagues within their state agency in a modified snowball sampling plan.

Despite rigorous effort to ensure an accurate and current distribution list, 9 initial invitations representing 8 states were returned as undeliverable with error messages stating the recipient could not be identified or did not exist. Email addresses for those 9 rejected subjects were rechecked against on-line state agency web pages or directories. An updated email address was found for one of the 9 subjects and the invitation was re-sent. Alternate email addresses could not be found for the remaining 8 subjects so they were assumed to no longer be employed with their respective state agencies. The seniority stratification plan described above was used to identify additional subjects in the 7 affected states. A total of 151 participants from 47 states provided valid survey responses.

With regard to individual level variables, one of the three indicators for the latent variable of perception of network integrity was recoded to adjust for response direction.

Measurement of Study Variables

As previously identified, three latent constructs were evaluated in this study. Two reflect the state level variables of state disaster experience and state well-being. The state disaster experience construct includes presidential major disaster declarations and presidential emergency disaster declarations by state from 1995-2010. The state well-being construct includes two measures, the Human Development Index and the Social Vulnerability Index. Data for the third, perception of state emergency management network resilience, was collected at the individual person level. This construct was measured by the researcher designed Perception of Network Resilience (PoNR) survey administered to employees in state emergency management agencies.

Individual Level

The 33 item PoNR survey tool measured 5 individual respondent demographic variables (current state of employment, length of time employed in emergency management, length of time employed at current state agency, gender, and highest level of education) and 28 questions on a 10 point likert scale. Twenty-four of those questions surveyed respondent perceptions of the five constructs identified as indicators of state emergency management network resilience. Four questions evaluated perception of network rapidity, 6 questions evaluated perception of network redundancy, 4 evaluated perception of network resourcefulness, 4 evaluated perception of network robustness, and 6 evaluated perception of network relationships. Perception of state EM network integrity was measured by 3 additional questions that queried respondent's views on the power, readiness and connectedness of their state emergency management network. Finally, respondents were asked 1 question about their perception of current community resilience to disaster in their home state.

State Level

Demographics

State level demographic data obtained from the NEMA membership report included state budget dedicated to emergency management services and number of full time state emergency management agency employees. FEMA region was collected from the NEMA report and confirmed against a published FEMA web based region map. Population for each state was retrieved from the 2010 United States Census Report. Given the differences between states in size, population, and agency organizational structure, basic budget comparison is not an accurate means of comparison across states. Some comparison can be achieved, however, by determining the average expenditure of each state emergency management agency per citizen. For example, if a State emergency budget is $1,000.00 and it has 1000 residents, per person spending is $1.00. For the purpose of this study, budget was defined as average state emergency management agency expenditure per state citizen.

Disaster Experience

State disaster experience is comprised of two indicators in this study, presidential major disaster declarations and presidential emergency disaster declarations. Both types of presidential declarations reflect an environment where joint state and local capacity to deliver the resources required for the state to recover from a disaster or event are exceeded. State Governors may request federal assistance under the Stafford Act to augment state and local response efforts. Enacted in 1988 to amend the Disaster Relief Act of 1974, the Stafford Act establishes the legal authority for most Federal disaster response activities, chiefly as they pertain to FEMA programs and resources.

To request relief under the Stafford Act, the governor of an affected state seeks a presidential declaration by submitting a written request to the President through their FEMA regional office. The Governor's letter must certify that the severity and magnitude of the disaster exceed state and local capabilities. It must also confirm that Federal assistance is essential to supplement the efforts and resources of state and local governments and partners, to verify execution of the state's emergency plan; and certify adherence to cost sharing requirements.

Upon receiving a Governor's request, FEMA teams execute a preliminary damage assessment of the affected areas. Once FEMA regional and national office staff review both the Governor's request and preliminary damage assessment, FEMA provides the President with an analysis of the situation and a recommended course of action. Presidential emergency disaster declarations are issued for imminent disasters or to support life safety or rescue needs when expenditures are estimated to be less than $5 million dollars (Sylves, 2008).

State of Well Being

Social Vulnerability Index

"An imbalance between rich and poor is the oldest and most fatal ailments of all republics."
- Plutarch, Greek historian, c.100 A.D

It is increasingly understood that health is influenced largely by the locally specific built, natural, and social environments within communities—the social determinants of health

(Institute of Medicine [IOM], 2015a). It is important to consider the impact of emergency management related policy and practice change on community health status. In order to measure impact, it is necessary to first measure baseline community well-being. In an attempt to inform that baseline assessment, two measures of well-being were conceptualized for this study; the Social Vulnerability Index and the Human Development Index.

The Social Vulnerability Index (SoVI®) 2006-2010 is a synthesis of 30 socioeconomic variables identified via research literature review as impacting a community's ability to prepare for, respond to, and recover from hazards. Created by the Centers for Disease Control and Prevention, index data is drawn from the 2010 US Census and the Five Year American Community Survey. Data from the 2006-2010 version of the SoVi was used in this study. Researchers found that, in that 2006-2010 data, just seven significant components contributed to 72% of the variance in social vulnerability scores across U.S. counties (Cutter, Boroff, & Shirley, 2006). Those 7 significant domains include race and class; wealth; elderly residents; Hispanic ethnicity; special needs individuals; Native American ethnicity; and service industry employment. The Social Vulnerability Components Summary, a brief explanation of those population characteristics identified by the SoVI can be found in Appendix C. Since Social Vulnerability Index Data is collected at the U.S. Census tract level, it had to be aggregated and averaged to create a state level score for this study. This procedure did disallow the impact of population concentration on tract scores but was included because no other appropriate data was identified to measure vulnerability from the theoretical perspective of this study. Higher scores represent increased vulnerability due to decreased ability to prepare for, respond to and recover from disaster. Lower scores represent decreased vulnerability, or an increased ability among state residents to prepare for, respond to, and recover from disaster. See Appendix D for a table of Social Vulnerability Index scores by state.

Human Development Index

Like Plutarch, scholars have recognized the risk in believing that measures of national wealth alone can accurately reflect the welfare of a society for over 2,000 years. In the last 50 years, social policy and planning experts have warned that many economic development policies ignore or contribute to large areas of poverty and exclusion from economic and social progress (Noorbakhsh, 1998). Global recognition of this risk led to development of measures that recognized human capability as capital beyond the economics of a nation's production and consumption (Sen, 1984, p.496).

The most comprehensive of those measures to date is the Human Development Index (HDI), published annually by the United Nations Development Programme (UNDP, 2011) since 1990. The Human Development Index (HDI) is a composite measure at the country level of average achievement in three key domains of human development: longevity, knowledge, and standard of living (Sagar & Najam, 1998 & Despotis, 2005). Noorbakhsh identified the comprehensive HDI tool as better able to capture many aspects of human development than less adequate earlier indices like GDP and per capita income, which neglects distributional aspects of income equality (1998).

Early versions of HDI used life expectancy at birth as a proxy for longevity to reflect wellness, adult literacy as a proxy for educational achievement to reflect knowledge and gross domestic product as a proxy for income to reflect standard of living. All three measures are treated equally in the index with no proxy receiving extra weight in (Neumayer, 2001). HDI methodology was adapted in 2010 for the indicators measuring education and income. As a binary variable that only identified "literate/illiterate", adult literacy was found to be an inadequate measure of education. Average years of schooling and expected years of schooling were added to adult literacy as indicators of knowledge achievement. The income indicator of Gross Domestic Product was replaced by Gross National Income to reflect the importance of measuring the retention of value of income accrued to residents – not only the value of what was produced. Lastly, the HDI recognized the complexities of comparing economic indicators across 187 countries with different financial systems in 2011. In order to better address the comparative challenges those differences present, HDI data is first converted to a common currency indicator, Purchasing Power Parity (PPP) international dollars, that reflects a standard purchasing power. One international dollar in the United States is equivalent to one international dollar in Sierra Leone. GNI figures have been reported in PPP dollars since 2011 (UNDP, 2011). The HDI has faced critique for both its inability to account for cultural inequality between countries and it's lack of aptitude to determine how sustainable development standings may be (Hicks, 1997 & Neumeyer, 2001).

This study evaluated data from the American Human Development Index (HDI), a variation of the Human Development Index, as a component of the latent construct of state well-being. The American Human Development Index was adapted from the UNDP HDI to reflect US context and available data by Measure of America, a non-partisan, nonprofit program of the Social Science Research Council. The American HDI uses life expectancy at birth as a proxy measure for longevity, educational degree attainment and school enrollment as measures of knowledge, and median earnings as the indicator for standard of living. Data for the American HDI are collected from official U.S. government sources through the American Community

Survey of the U.S. Census Bureau and the Centers for Disease Control and Prevention. Lower HDI scores mean lower insulation against negative disaster related impact because the conditions that increase vulnerability are more prevalent. Data from the Measure of America Human Development Index scale was transformed to reflect the same directional level as the Social Vulnerability Index data so higher scores mean higher risk for both variables. HDI data was disaggregated by state for this research and can also be disaggregated by congressional district, gender, race and ethnicity (Lewis & Burd-Sharps, 2010). HDI scores by state can be found in Appendix E. Variable definitions and data collection methods are presented in Table 4 and Table 5.

Table 4. Endogenous Variables: Definitions and Sources of Information

Variable	**Definition**	**Source**	**Accessibility**
	Resilience		
Robustness	Index measure of inherent strength within state network that reflects resistance to resource or information exchange failure	PoNR Survey	Researcher Permission
Relationships	Index measure of the scope and strength of network member connectedness with federal, regional and state partners.	PoNR Survey	Researcher Permission
Rapidity	Index measure of speed with which network members can exchange resources and information within the state.	PoNR Survey	Researcher Permission
Redundancy	Index measure of systemic network properties that allow for substitution of services and exchange of resource and information within the state.	PoNR Survey	Researcher Permission
Resourcefulness	Index measure of capacity of network to mobilize collective resources and efficiently establish collective priorities within the state.	PoNR Survey	Researcher Permission

Table 5. Exogenous Variables: Definitions and Sources of Information by Level

Variable	Operational Definition	Source of Information	Accessibility
Individual			
Years Work	Years worked in emergency management field	PoNR Survey	Researcher permission
Years Agency	Years worked at current state emergency management agency	PoNR Survey	Researcher permission
Gender	Gender	PoNR Survey	Researcher permission
Education	level of education achieved	PoNR Survey	Researcher permission
State	State of current employment @ emergency management agency	PoNR Survey	Researcher Permission
Network Integrity			
Integrity_1	Measure of insulation (distance) between State Emergency Mgmt Network and communities within the state.	PoNR Survey	Researcher Permission
Integrity_2	Measure of fairness and equity of distribution of power in economic and policy decision making across network partners within the state.	PoNR Survey	Researcher Permission
Integrity_3	Measure of Network capacity to respond collaboratively to an emergency or disaster	PoNR Survey	Researcher Permission
Community Resilience			
Community Resilience	Capacity of all communities within the state to respond with strength in the face of adversity to	PoNR Survey	Researcher Permission

Variable	Operational Definition	Source of Information	Accessibility
	reach a higher level of function in recovery.		
State			
Demographics			
Full Time State Employees	# of full time emergency management employees in the state	2010 NEMA Annual Report	Member subscription
State EM Budget	Amount of state emergency management agency budget PER citizen	2010 NEMA Annual Report	Member subscription
Population	State population per 2010 U.S. Census	U.S. Census	Public information
FEMA Region	1 of 10 geographic multi-state areas served by a FEMA office	FEMA.gov	Public information
State Disaster Experience			
MDD	Major Presidential Disaster Declarations from 1995 -2010	FEMA.gov	Public information
EDD	Emergency Presidential Disaster Declarations from 1995 - 2010	FEMA	Public information
State Well Being			
HDI	Human Development Index	Measure of America Index 2010/11	Public Information
SoVI	Social Vulnerability Index	Hazards & Vulnerability Research Institute	Public Information

Development of the Analytical Model

The goal of this research was to better understand the attributes of formal and informal relationships that contribute to resilience among state emergency management networks. Structural equation modeling was identified as the analysis technique most appropriate for this research. The findings generated from this study could allow network actors to more efficiently prioritize activities that build trust and exchange within the network to increase network resilience. Networks, as adaptive complex systems, have the capacity to mobilize collective memory of experiences to develop horizontal and vertical collaboration to govern resource management (Norberg, Wilson, Walker & Ostrom, 2008).

Study Aim 1

The goal was initially addressed by defining measurement of network resilience specific to state emergency management (EM) networks via the first study aim, to determine if network resilience can be validly measured by state emergency management agency employee perception of the constructs of network redundancy, network rapidity, network resourcefulness, network robustness and network relationships. Each construct was measured by 4 to 6 questions in the researcher designed Perception of Network Resilience survey tool (see Figure 6). Methodology for this aim included correlation analysis, analysis of scale validity, and confirmatory factor analysis for the measurement model.

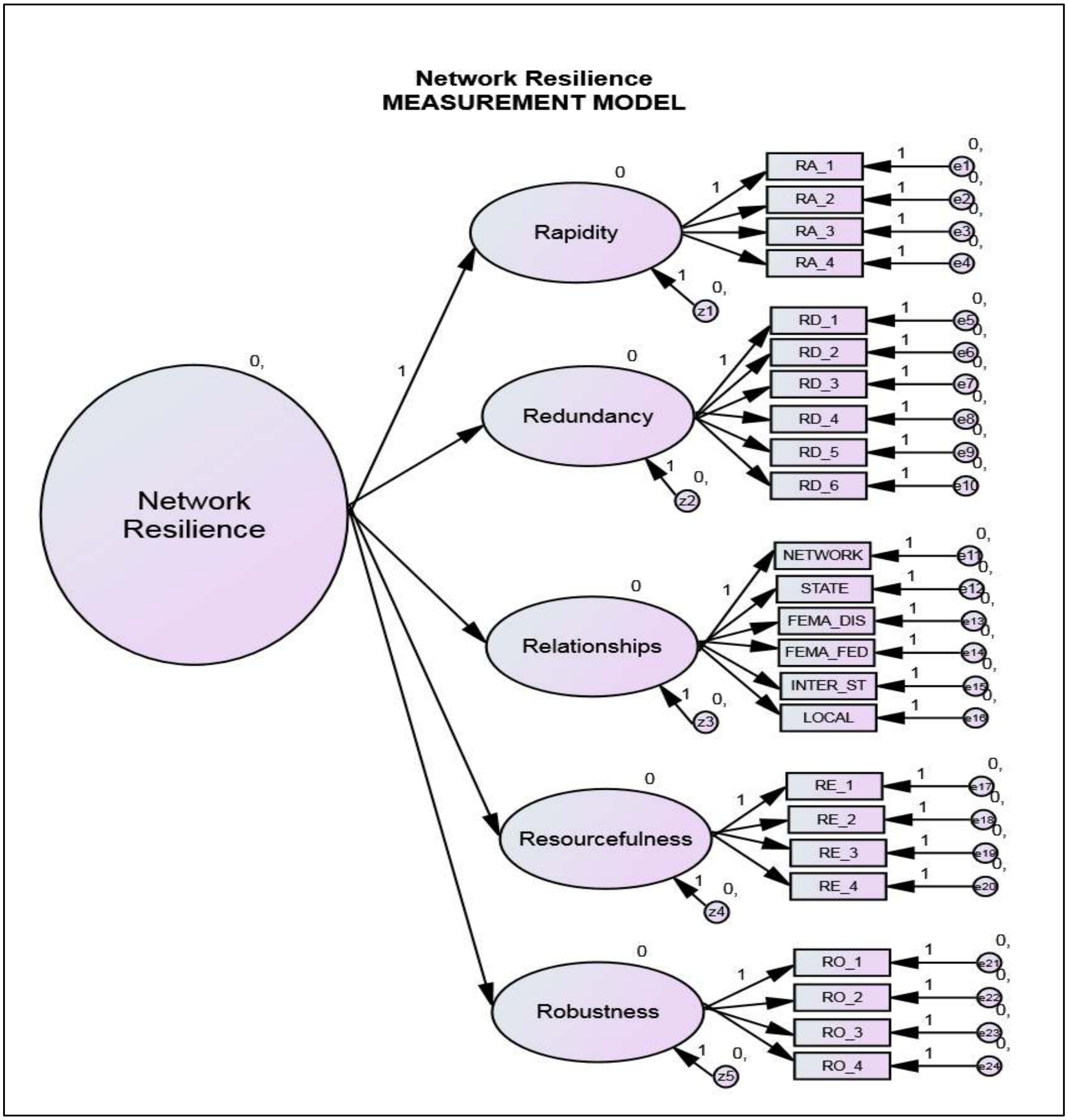


Figure 6. A Second-Order Factor Measurement Model of Perceived Network Resilience with Five Domains or Five First-Order Factors

Study Aim 2

The study goal was also addressed by the second aim of the study to determine if specific individual-level indicators can predict perception of emergency management network resilience.

These predictors include individual demographic measures of length of work experience in the emergency management field, length of work experience at their current state emergency management agency, gender, level of educational attainment, perception of community resilience, and the latent variable perception of network integrity, which is comprised of three indicators. It is hypothesized that specific individual level variables may influence the opportunity for resource and exchange between state emergency management network agencies and affect resilience.

With regard to time, a longer time in a field or agency role can increase the likelihood that an individual in a state emergency management network would come in contact with other emergency management network entities to exchange information or resources and in turn, increase the opportunity to develop relationships of trust.

Educational attainment may influence perception of network resilience because more advanced study may reflect advanced exposure to emergency management network concepts and increased capacity to recognize and appreciate the elements of a resilient network. Gender is identified as a possible influential indicator based on the common perception that women have stronger relational skills, which may indicate a higher level of perception about those relationships that affect network resilience.

Since some communities are lauded for being more resistant to disaster impact, community resilience is included as a possible individual level predictor variable of network resilience to determine if there is a relationship between disaster resilient communities and perception of network resilience. For example, London was "resilient" in the wake of coordinated suicide bombings in 2005, businesses need to be "resilient" to be successful in the face of terrorism, and the stock market was "resilient" after the 9/11 bombings (Dougherty, 2005). Finally, perception of network integrity is evaluated as a possible predictor of perception of network resilience via three questions that assess perceptions of network insulation, distribution of decision making power, and collaborative readiness.

Methodology for this aim included correlation analysis and confirmatory factor analysis of a measurement model for network integrity (Figure 7).

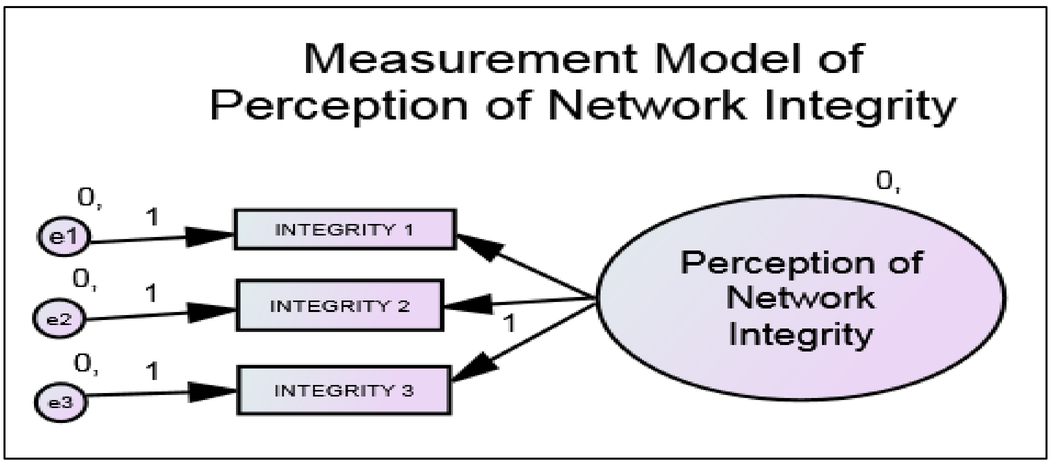


Figure 7. Measurement Model of Perception of Network Integrity

It also included a structural model that explored the relationships between the predictor variables of individual demographics (state, gender, length of time employed in emergency management, length of time employed at current state agency, and educational attainment), perception of community resilience, and perception of network integrity on perception of network resilience (Figure 8).

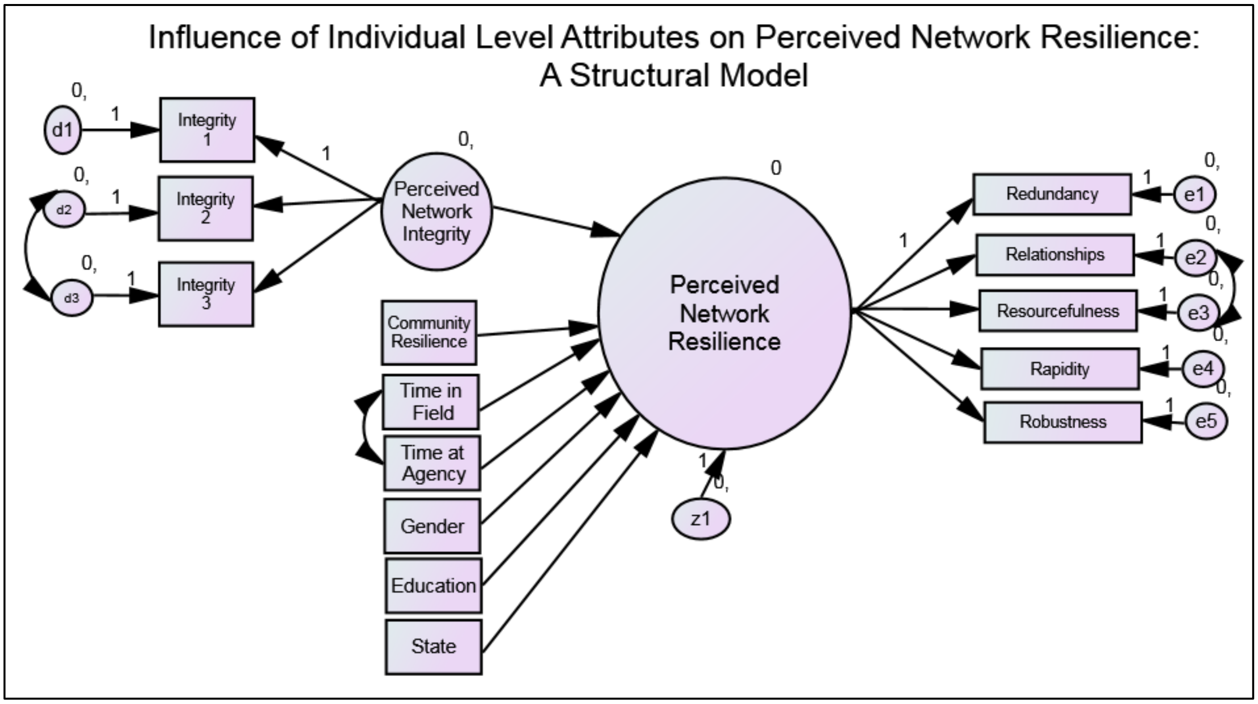


Figure 8. Initial Structural Model for Individual Level Predictors of Perceived Network Resilience

Study Aim 3

The third aim of this research addressed the study goal by determining if specific state level indicators can predict perception of state emergency management network resilience. State level ecological indicators include disaster history, state well-being and state demographics including population, state emergency management budget, full time emergency management employees and FEMA region. It is posited that an EM network's resilience would be influenced by the amount of experience that state network had responding to disasters. The more experience emergency management network entities have working with each other, the more likely they are to have opportunities to exchange resources from tanker trucks to information. Resource exchange is the mechanism by which network members develop trust in each other – a trust that allows them to attain a state of resilience that increases the integrity of the network and allows the whole to be more than the sum of the parts.

Methodology for this aim included correlation analysis and covariance structure analysis of a predictive model (Figure 9) that explored the relationship between state disaster experience from 1995- 2010, state well-being, state demographic data and state emergency management employee perception of their network's resilience. Disaster experience was measured by FEMA data on presidential major disaster declarations and presidential emergency disaster declarations from 1995-2010. State well-being was measured by the Social Vulnerability Index and the American Human Development Index. Demographic data was collected from the National Emergency Management Association, FEMA, and the U.S. Census. Network resilience was measured by state emergency management agency employee response to the PoNR survey.

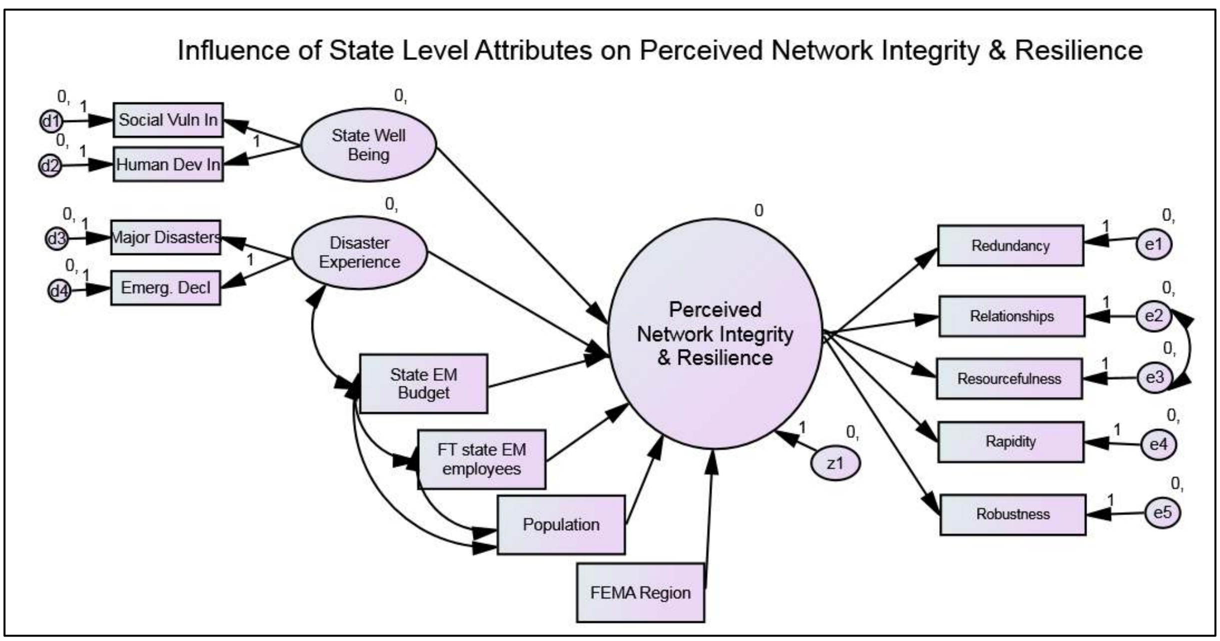


Figure 9. Initial Structural Model for State Level Predictors of Perceived Network Resilience

Study Aim 4

The study goal was also addressed by the fourth and final aim of this research, to determine if state level variables are more influential than individual-level variables in explaining the variability in perceived emergency network resilience. Ecological state level variables included the number of full time employees in the state emergency management agency, percentage of state budget allocated to emergency management activity, state population and FEMA region. State well-being was measured by the Social Vulnerability Index and the Measure of America Human Development Index. Methodology for this aim included confirmatory factor analysis to evaluate a two-level analytical model that combined both individual and state level variables (see Figure 10).

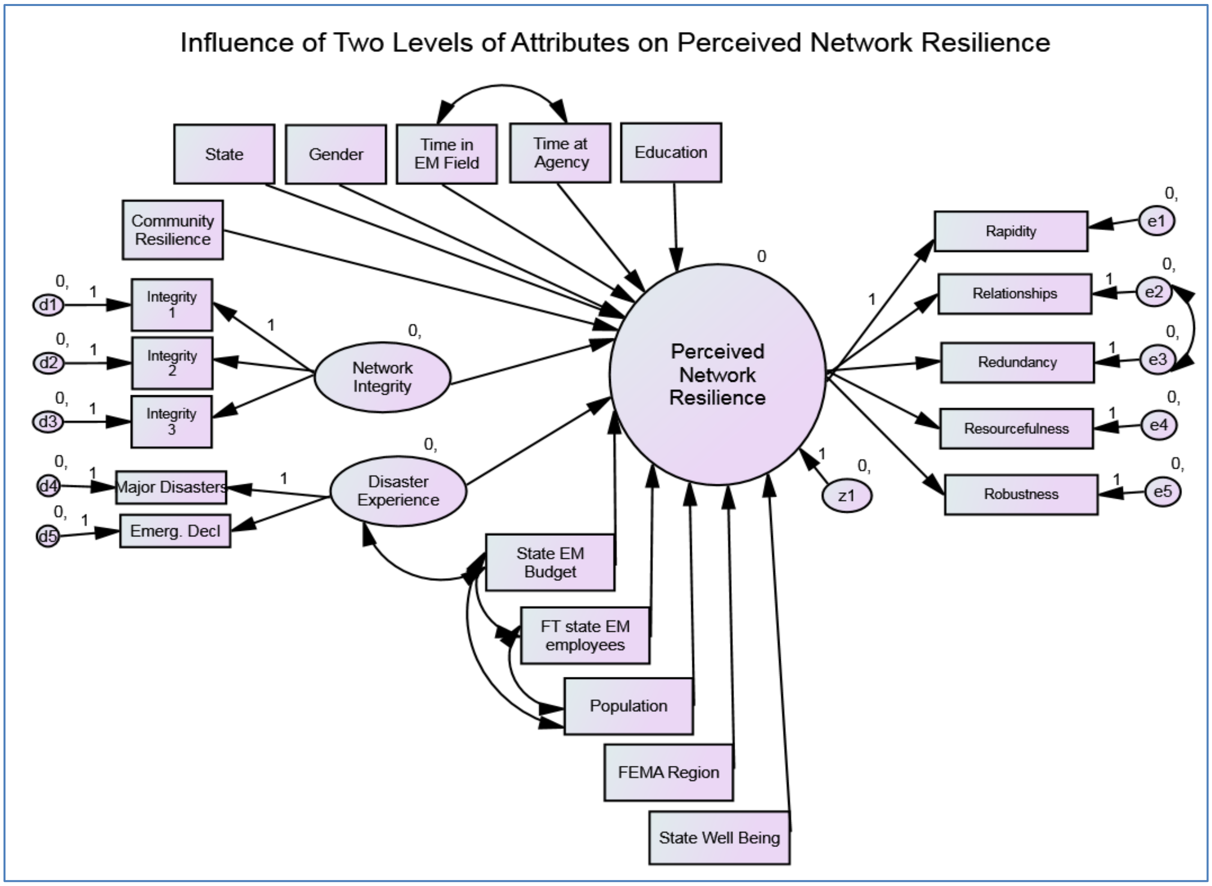


Figure 10. Proposed Two-Level Structural Model of Predictors of Perceived Network Resilience

<u>Analysis</u>

Data were analyzed by descriptive statistics, correlation analysis, and structural equation modeling (confirmatory factor analysis and path analysis) in IBM SPSS Statistics software across versions 19-22 and AMOS graphics software. Data cleaning was performed to analyze data integrity. Missing data was transformed first by case screening to identify missing data, unengaged responses, and outliers. Descriptive statistics including frequency, minimum, maximum, mean, and standard deviation were performed for each variable as an initial examination of the distribution of the data and to check for errors.

Data was assessed for normality by visual inspection of histograms and box plots for distribution symmetry and by statistical test for skewness and kurtosis. Scores from Shapiro-Wilk's and Z-testing were obtained. Z-testing was performed by dividing the skew and kurtosis values by their own standard error. For a sample size between 50 and 300, absolute z-scores under 3.29 reflect a normal distribution (Kim, 2013). In a normal distribution, a skew value of zero would imply symmetric distribution. A positive skew value indicates that the distribution tail to the right is longer than the tail to the left, and that more values lie to the left of the mean. A negative skew value indicates that the distribution tail on the left side is longer, and the majority of the values lie to the right of the sample mean. A positive kurtosis suggests the sample distribution is highly peaked, while a negative kurtosis suggests the distribution is more platykurtic, or flatly distributed.

Descriptive statistics were analyzed for state ecological variables and PoNR survey responses. Correlation analysis was performed to identify linear association between variables. Where parametric tests are indicated for correlation analysis, Dancey and Reidy (2002) suggest the strength of the correlation be interpreted using the absolute value of *r* where

- 0.0 is "zero"
- .10-.39 is "weak"
- .40-.69 is "moderate"
- .70-.99 is "strong"
- 1.0 is "perfect"

Confirmatory factor analysis was used to evaluate the measurement models for Network Resilience (see Figure 6) and Network Integrity (see Figure 7) and assess validity and reliability of the PoNR resilience scale via Cronbach's alpha coefficient, a measure of internal consistency for a single administration scale (Suhr & Shay, 2009). Confirmatory factor analysis is a theory driven technique wherein a hypothesis driven model is used to predict a population covariance matrix that is then compared to an observed covariance matrix obtained from data (Schreiber et al, 2006). Confirmatory factor analysis reduces measurement error by allowing multiple indicators per latent variable. This technique evaluates the way data fits into a model developed with guidance from logic and theory, which differs from exploratory factor analysis, a technique to search through the data to identify a model based on statistical relationships identified by the data set.

Structural equation modeling (SEM) is an appropriate method for data analysis in this study because it is considered a combination of factor analysis, latent growth modeling and regression or path analysis (Hox & Bechger, 2007). SEM allows more flexible assumptions than multiple regression, especially in the allowance of interpretation with multicollinearity. SEM methods allow hypothesis testing of the theoretical structure of causal forces that influence complex relationships. Because SEM demands that relationships between variables be specified in a structural model before analysis, it is useful to test theoretical propositions of causality.

Model fit was evaluated via analysis of several goodness-of-fit indices. Just as a 12-lead EKG provides much more comprehensive data about the integrity of the heart than a 3-lead EKG due to the use of more data point perspectives, multiple goodness-of-fit indicators are required to complete a robust model assessment, as each single measure only provides information on certain aspects of the model (Mulaik et al, 1989).

Several goodness of fit indices were analyzed to evaluate the study models, as each index evaluates certain aspects of each model so no single index can successfully measure model fit (Mulaik et al, 1989). The chi square statistic is the most frequently used test in structural equation modeling. Chi-square tests whether the estimated covariance matrix and the observed covariance matrix converge toward zero as sample size increases to reflect. A significant chi-square sometimes indicates a model is not acceptable, although this measure can be disregarded when sample sizes are large or other indices indicate acceptable fit because complexity, sample size, and violation of normality can all influence accuracy. When the chi-square is insignificant, the model is accepted.

The Comparative Fit Index, or CFI, is recommended for routine use as an incremental fit index to measure proportional improvement in fit between the target model and an independence model. Both the CFI and RMSEA are considered independent of sample size (Fan, Thompson, and Wang, 1999). The closer the CFI is to 1, the better the fit. CFI should be $\geq$ .93 to accept the model (Byrne, 1994).

The Tucker-Lewis Index is also a measure of incremental fit. Model fit is less likely to be overestimated as parameters increase with TLI than with the earlier NFI, or the Bentler-Bonett normed fit index. A TLI over .90 or .95 is considered acceptable (Hu & Bentler, 1999).

Root mean square error of approximation, or RMSEA, is based on a residuals matrix that looks at discrepancies between predicted and observed covariances. A parsimony adjusted measure, RMSEA penalizes models complicated by excessive parameters. There is adequate model fit if RMSEA is less than or equal to .08. Hu and Bentler suggest a RMSEA $\leq$ .06 as the cutoff for a reasonably good model fit (1999).

Finally, qualitative responses of the PoNR were analyzed for trends and themes. Respondents were given the opportunity to share any additional thoughts or feedback for each of the 33 survey questions.

CHAPTER FOUR: RESULTS

Study findings are reported in three sections. The first section, exploratory analysis, presents descriptive statistics about the sample data. The second section includes descriptive analysis of all survey results and discussion of qualitative survey responses to the researcher developed survey tool. The third section summarizes results for each hypothesis including confirmatory analysis of a measurement model and structural equation results for one individual, one state, and one two level analytical model.

Exploratory Analysis

A total of 157 surveys were returned over a 3 month period between May and August 2011. Respondents reported working for state emergency management agencies in 47 states, representing all 10 FEMA regions (see Table 6). The four states with no respondents were from FEMA regions 1, 4, 7, and 10.

Table 6. States Represented in Survey Responses by FEMA Region

FEMA	Number of States
Region 1	5
Region 2	2
Region 3	6
Region 4	7
Region 5	6
Region 6	4
Region 7	4
Region 8	6
Region 9	4
Region 10	3

Missing variables in 6 survey responses were imputed. Responses from one participant were found to have a standard deviation of 0.00, which suggests no variability in their responses so this survey participant was discarded. Visual inspection of responses from 5 other participants revealed inadequate variability at standard deviations of 0.1 to 0.2 so those surveys were also discarded. All other responses reflected a standard deviation of >0.3 with visual confirmation of appropriate variability in responses so a total of 151 engaged and completed surveys were available for analysis.

While respondents were assured that the survey was anonymous, they were offered the opportunity to provide contact information so a summary of the findings could be provided to them upon study completion. One hundred seven (70%) of the 151 respondents provided contact information for that purpose. Contact information was removed from the research data file prior to analysis for ensuring confidentiality.

Normality tests for skewedness and kurtosis, Shapiro-Wilk's test ($p>.05$) (Shapiro & Wilk, 1965; Razali & Wah, 2011) and visual observation of histograms, normal Q-Q plots and box plots suggest that survey scores were normally distributed with no improbably outliers for male and female respondents. Z-test scores confirm normal distribution, as none were higher than ± 3.29. Skewedness and kurtosis scores are reported in Appendix E for individual level exogenous variables, and singular and indexed endogenous variables from the Perception of Network Resilience survey.

The number of surveys returned by each state ranged from 1 to 10. The sample goal of four or more returned surveys was met by 17 states. Return distribution is illustrated in Table 7.

Table 7. Perception of Network Resilience Survey Responses by State

Survey Responses by State					
Respondents	**# of States**	**% of Responses**	**Cumulative % of Responses**	**% of States Responding**	**Cumulative % of States Responding**
1 response	9	5.8%	5.8%	19.2%	19.2%
2 responses	14	18.5%	24.3%	29.8%	49.0%
3 responses	7	13.8%	38.1%	14.9%	63.9%
4 responses	7	18.4%	56.5%	14.9%	78.8%
5 responses	2	6.7%	63.2%	4.3%	83.1%
6 responses	4	15.8%	79.0%	8.4%	91.5%
7 responses	2	9.3%	88.3%	4.3%	95.8%
8 responses	1	5.3%	93.6%	2.1%	97.9%
10 responses	1	6.4%	100.0%	2.1%	100.0%

Of those returned surveys, 40 were completed by women (27%) and 110 by men (73%). Respondents reported an average number of 13.2 years of experience in Emergency Management. Women reported an average of 11.5 years of emergency management experience, ranging from 2 to 30 years. Men reported an average of 14.3 years of emergency management experience with a range of 45 years (less than 1 year to 45 years). Respondents reported being employed at their current State emergency management agency for an average of 8.6 years. Women reported an average length of employment at their current agency of 9.3 years with a range of 25 years (less than 1 year to 25 years). Men reported an average length of employment at their current agency of 8.3 years with a range of 33 years (less than 1 year to 33 years). Only 3 women reported being in emergency management for 25 years or longer (8%) compared to 20 men (18%). A full 70% of men reported being in emergency management for less than 10 years (n=77) compared to just 55% of women (n=22).

Approximately 5% of respondents reported their highest educational attainment as high school. 7% of women and 10% of men reported 2 year college degrees. 37% of women and 40%

of men reported holding 4 year college degrees. While only 5% of women reported a post college certificate, 42% (n=19) reported a graduate degree or post graduate certificate compared to 12% of men reporting post college certificates but only 30% (n=33) holding graduate degrees or post graduate certificate. Four men reported holding PhD, JD, or other doctoral degree but no women reported any doctoral degrees.

Perception of Network Resilience Survey Analysis

Basic statistics and trends in Perception of Network Resilience survey data are presented. The 33 item survey evaluated respondents' perceptions of network integrity, community resilience, and five latent constructs of network resilience, network rapidity, network redundancy, network relationships, network resourcefulness, and network robustness. All measurement scales were assessed using a 9-point likert scale. See Appendix E for descriptive statistics related to the construct indicators. Demographic data was collected with the first 5 survey questions. Respondents were invited to share additional information for each of the following 28 questions. An average of 22 qualitative responses were received per question with a range of 5-44 responses per question.

The latent variable of rapidity was evaluated by asking respondents about their perception of how quickly they thought network entities could respond to any request from them or mobilize to fulfill most of their responsibilities during both emergency and nonemergency states. Respondents reported that they thought their network would mobilize more quickly in an emergency than in a non-emergency to both do their own work (mean score =7.23 vs. 6.09, n=151) and respond to requests for resources (mean = 7.38 vs. 5.94, n=151).

Additional qualitative information provided by respondents described expectations for network activation during emergency of anywhere from "immediately" to 2 hours depending on the type of event. During a non-emergency, respondents suggested that requests are more likely to be addressed within 4-24 hours, but that some agencies still work to respond within the same 2 hour window they use to benchmark response during an emergency. Respondents credited non-emergency environments of constant joint planning, training, and exercising as very valuable to improving collaboration and the likelihood of response but also suggested a better measure for non-emergency responsiveness may be comprehensiveness, not rapidity.

The latent variable of redundancy was measured by evaluating employee perception of the frequency with which two or more network entities performed the same roles or functions, the likelihood that one network entity could perform the work of another if the original failed, and the likelihood of resource (personnel, equipment, supplies) sharing between entities during both emergency nonemergency states. Respondents again felt that response during emergencies would be better than during a nonemergency state, with mean scores of 4.25 vs 4.07 (n=151) for frequency of entities performing redundant roles and functions, 6.13 vs. 5.17 (n=151) for likelihood of redundant work performance after entity failure, and 7.15 vs. 4.79 (n=151) for frequency of resource sharing.

It is important to note that both the literature and earlier analysis of the rapidity construct in this study suggest that communication and shared planning and preparedness training during non-emergency states are valuable activities, yet there is a significant difference in respondent's perception of the frequency with which resources are exchanged during different emergency states in this study, with the majority reporting that exchange occurs "very often" during emergency but "not at all often" during nonemergency states.

Additional qualitative responses to questions in the redundancy scope reiterated the conflict inherent to emergency response – some respondents felt that there was adequate communication around hazard and vulnerability assessments to allow the network to identify resource gaps which they then filled with cross training, MOUs, or shared purchasing. Other respondents pointed out that, for many network entities, job functions during an emergency state are different from job functions during a nonemergency state so comparison may not reflect accurate assumptions.

The latent variable of relationships was measured by evaluating respondent perception of the strength of their state emergency management network and the strength of relationships between their state emergency management agency and other in-state network agencies, out-of-state agencies in their network, their regional FEMA office, the federal FEMA office, and local governments in their state. On a scale of 1-9, higher scores reflect stronger relationships. Respondent identified relationships with regional FEMA offices as the strongest and relationships with out-of-state entities in their networks as the least strong.

Qualitative responses to this construct consistently identified politics, budgets, and staffing constraints as threats to network strength. Respondents again identified the importance (and challenge) of understanding what may be very different partner agency roles in emergency and nonemergency states. Technical assistance with training and good communication between agency leadership roles were most frequently reported to positively influence relationship strength with regional FEMA offices. These FEMA regional office services were also listed most often as contributing to relationship strength between state emergency management network agencies and out-of-state network partners. Respondents reported lack of contact and agency disorganization as frequent influences of their perception of relationship strength with the federal

FEMA office but some respondents did state that national FEMA staff was responsive and expert when they were called. Respondents reported that time and capacity disparities had a significant influence on the strength of agency relationships with local governments.

The latent variable of resourcefulness or measured employee confidence in the ability of network member organizations to establish collective emergency management priorities (mean= 7.07, n=151), mobilize emergency management resources like personnel, equipment and information (mean = 7.50, n=151), efficiently exchange those resources (mean = 6.92, n=151), and identify and address collective problems related to emergency management (mean = 6.85, n=151). Qualitative responses suggest that formally established structures like Multi-Agency Coordination (MAC) and the Governors Executive Policy Decision Group make establishing collective emergency management priorities easier, especially when after-action reports are widely disseminated. Some respondents suggest that formal systems like mutual aid agreements also make mobilizing emergency management resources easier, while others identified less formal activity like training and exercising as important to develop a common operating picture. Respondents consistently identified the state emergency management agency as the primary entity responsible for successful coordination of resource exchange. Respondents also reported that formal mechanisms like advisory committees, technical working groups or advisory boards have helped guide collective problem solving in their state networks.

The latent variable of robustness evaluated employee perception of the degree to which network member organizations were connected both to the state emergency management agency and to each other. It also evaluated perception of the most appropriate number of agencies for optimal network strength and perception of the network’s resistance to stress. Respondents felt network organizations were more connected with the state emergency management agency (mean=7.13, n=151) than with each other (mean=6.52, n=151).

With regard to network size, 11% of respondents felt the network would be stronger if member entities were removed, 80% of respondents felt no adjustment to the number of network entities was needed to improve strength, and 9% felt network strength would be improved by adding members. Finally, 5% of respondents felt their state emergency management network would begin to suffer a loss of performance and function at the lowest level of stress. More than half of respondents (52%) felt their network would experience such a loss under a moderate level of stress, while 43% felt their network performance and function would only begin to suffer under the highest level of stress. Qualitative submissions varied widely regarding network resistance to stress. Some respondents reported that stress itself, usually experienced in the form of a response, strengthened the network while others felt lean economic times created stress that impacted network performance. A few respondents felt that the nature of network development activities like collaborative planning and training was protective against stress, imbuing network performance with a higher threshold of stress resistance.

Three questions surveyed employee perception of network integrity, a latent variable. Respondents were asked about the degree of insulation between the network members and their local communities, about the distribution equity of decision making power across the network, and about the current state of network readiness to collaborate during an event response. 94% of respondents felt their network was not at all or only somewhat insulated from their community. Only 6% felt their network was very insulated. Respondents reported that high levels of insulation levels were unlikely because emergency management partners are also community members, living in the places they work. That duality tends to disallow isolation, as most emergency preparedness and response activity happens at very local levels. Factors attributed to increased isolation include politics and communication challenges.

Over half of respondents felt the power to make economic and policy decisions was distributed somewhat fairly and equitably (56%), while 16% felt it was not at all fairly distributed and the remaining 28% perceived the distribution of power to be very equitable. Respondents differentiated between decisions related to issues of state level authority that are conferred by statute or legislation with those decisions that individual entities have the authority to interpret. Respondents recognized that often, economic and policy decision making is a function of executive state leadership but also acknowledged that strong network solidarity and consensus outside of the executive level could influence decisions.

Finally, 72% of respondents felt their entire emergency management network was very well prepared to respond collaboratively to an emergency. Only 5% felt their network was not well prepared, with the remaining 23% reporting they felt their network was somewhat well prepared to mount a collaborative response to an emergency or disaster. All 10 of those employees who shared that their network was actively responding to an emergency at the time of their survey participation also expressed that their current collaborative experience was positive.

Participants were asked how resilient they felt the communities in their home state currently were to disaster given a definition of community resilience as ‘the ability of a community to respond with strength in the face of adversity, and in so doing reach a higher level of function in recovery’. Almost a third of respondents felt their communities were very resilient to disaster (32%), 55% believed their communities were somewhat resilient, and only 12% felt their communities were not at all resilient. Respondents shared additional perspectives on community resilience that reflected beliefs that communities have more capacity to be resilient than individuals, that some communities could recover from an event and be stronger in the face of the next disaster, and that, while practice makes perfect, some communities have limited ability to invest in reducing risk so small losses can be more devastating to them because they have less capacity to absorb the impact.

Since normality tests showed scaled data to be predominantly normally distributed, correlation coefficients were measured by Pearson's product-moment correlation (r) to determine degree of linear relationship, or strength of relationships, between variables.

Hypothesis Testing and Analysis

Hypothesis 1

Hypothesis 1: Network resilience can be validly measured by the constructs of redundancy, rapidity, resourcefulness, robustness, and relationships.

Correlation analysis of each of the factors in all five of the model constructs was performed. One question in the construct of rapidity was removed, as results were found to be uncorrelated with any other indicators in the construct. A correlation table for individual level variables is in Appendix F. Following correlation analysis, exploratory factor analysis (EFA) of the measurement model for network resilience was completed. EFA is a statistical technique used to evaluate a measurement model without a priori knowledge of how the designated indicators may be related to the latent construct. It allows identification of relationships among sets of observed values in terms of an unobserved, latent construct and test hypotheses (Wan, 2002). Since latent constructs are measured by observed indicators, the more the variation in the construct can be explained by observed variable indicators, the more rigorous the measurement model (Kline, 2005).

Based on correlation analysis and EFA results, iterative analysis of the initial network resilience measurement model resulted in consolidation of 23 questions addressing the 5 constructs of resilience in state EM networks (rapidity, redundancy, relationships, resourcefulness, robustness) to an indexed measurement model with 5 first-order factors or sub-constructs. The indexed measurement model is illustrated in Figure 11. Correlation coefficients for the Perception of Network Resilience Scale can be found in Appendix G.

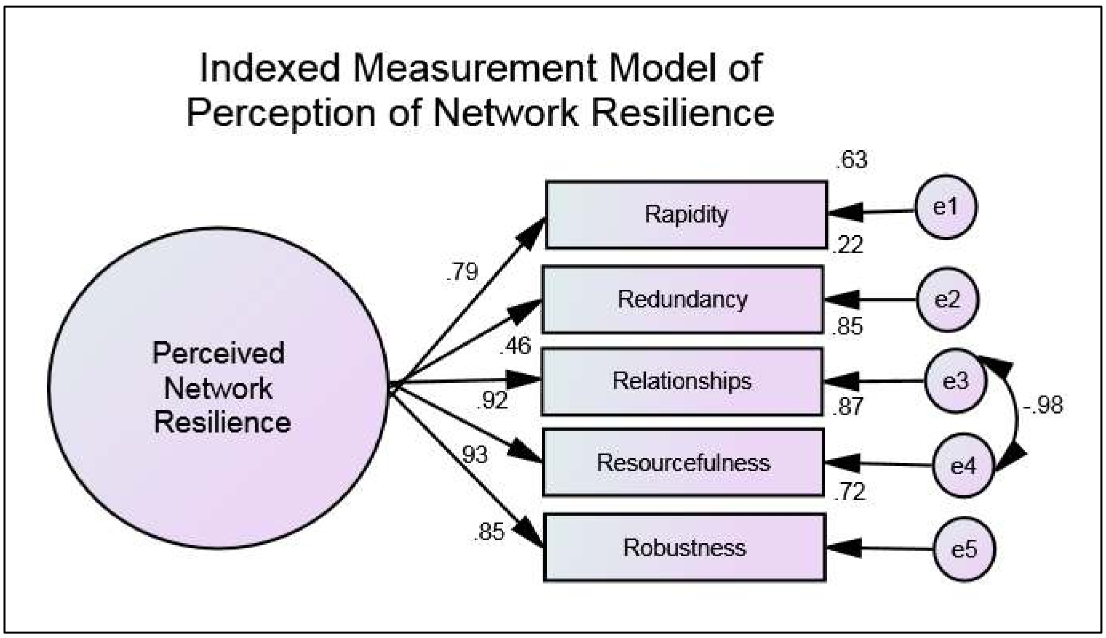


Figure 11. A Measurement Model of Perceived Network Resilience, a Latent Endogenous Variable

Constructs in the first order measurement model of network resilience were moderately to highly correlated with each other. Correlation indices can be found in Appendix G. The indexed measurement model for perceived network resilience included the constructs of rapidity, redundancy, relationships, resourcefulness, and robustness. For this model, a $\chi^2 = 5.012$, 4df, $p=.286$ and $\chi^2/df = 1.253$ was not significant, which suggests that the proposed model has an excellent fit to the data and is consistent with observed data. Goodness-of-fit indices support acceptance of the revised index model with a CFI=.998, TLI=.992, and RMSEA=.041. A summary of parameter estimates for the indexed model in Figure 10 can be found in Table 8.

Table 8. Maximum Likelihood Estimates for the Indexed Measurement Model of Perceived Network Resilience

			Unstandardized Estimate	S.E.	C.R.	P	Standardized Estimate
Red_I	<---	Perc_NR	1.000				.464
Relat_I	<---	Perc_NR	2.429	.399	6.086	***	.921
Resou_I	<---	Perc_NR	2.434	.398	6.114	***	.933
Robust_I	<---	Perc_NR	1.431	.235	6.095	***	.851
Rapid_I	<---	Perc_NR	1.645	.277	5.941	***	.792

Once indexed, all five indicators for network resilience were found to be valid measures of perception of network resilience. The hypothesis that resilience can be validly measured by the constructs of redundancy, rapidity, resourcefulness, robustness, and relationships is accepted.

Hypothesis 2

Hypothesis 2: Specific individual level indicators can predict perception of emergency management network resilience.

Individual level indicators included the demographic measures of length of time employed in the field of emergency management, length of time employed at current state emergency management agency, gender and level of educational attainment. Perception of network integrity and perception of community resilience were also evaluated as individual level predictor variables of perception of network resilience.

Analysis of Pearson correlation coefficients in individual level respondent demographic data from the PoNR survey demonstrated a moderate but statistically significant relationship between years worked in emergency management and years worked at current state agency for female respondents ($r=.529$, $n=41$, $p<.000$) with a longer time working in the field of emergency management moderately associated with a longer time working at current state agency. For men, the length of time employed in the field of emergency management was also moderately correlated with length of time working at current state agency ($r=.569$, $n=110$, $p<.000$).

Significant correlations were found at the 0.01 level between perception of community resilience and each of the three variables for network integrity and each of the five indexed variables for network resilience. A moderate correlation of .593 was found between community resilience and perception of network preparedness to respond collaboratively to an emergency. Strong correlations were found between network integrity variables and network resilience variables with the strongest between the network resilience measures of robustness and resourcefulness at ($r=.796$, $n=151$, $p<.000$).

The first indicator of the latent construct of network integrity was found to be weakly correlated with network integrity indicators 2 and 3, whereas 2 and 3 were found to be moderately correlated with each other. Correlation coefficients for the construct of network integrity can be found in Appendix G. Confirmatory analysis of the measurement model for network integrity in Figure 12 was performed.

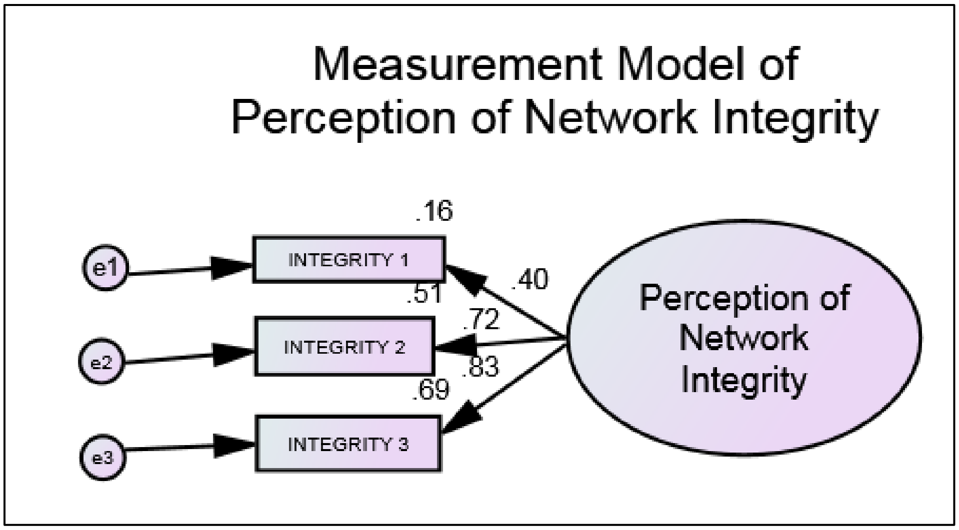


Figure 12. Measurement Model of Perceived Network Integrity

With a $\chi^2 = .000$ and Df = 9, no p value could be computed because this is a just-identified model with no goodness of fit measures provided. This model is a just identified model, so it is acceptable as a latent construct of network integrity. A summary of parameter estimates for this model can be found in Table 9.

Table 9. Maximum Likelihood Estimates for the Measurement Model of Perceived Network Integrity

			Unstandardized Estimate	S.E.	C.R.	P.	Standardized Estimate
INTEG_3	<--	Per_NI	1.000				.790
INTEG_2	<--	Per_NI	1.091	.235	4.549*	***	.753
INTEG_1A	<--	Per_NI	.093	.022	4.168*	***	.466

*Statistically significant at a level of 0.05 or lower

Upon acceptance of the measurement models, the influence of individual level attributes on perception of network resilience was analyzed in a structural equation model. In structural equation modeling, explanatory models are developed, tested, and verified or revised in order to better fit the data (Unruh & Wan, 2004). The structural model for individual level attributes included one construct (network integrity) and 6 variables; state of employment, length of time employed in the emergency management field, length of time employed in current emergency management agency, gender, education and perception of community resilience (Figure 13).

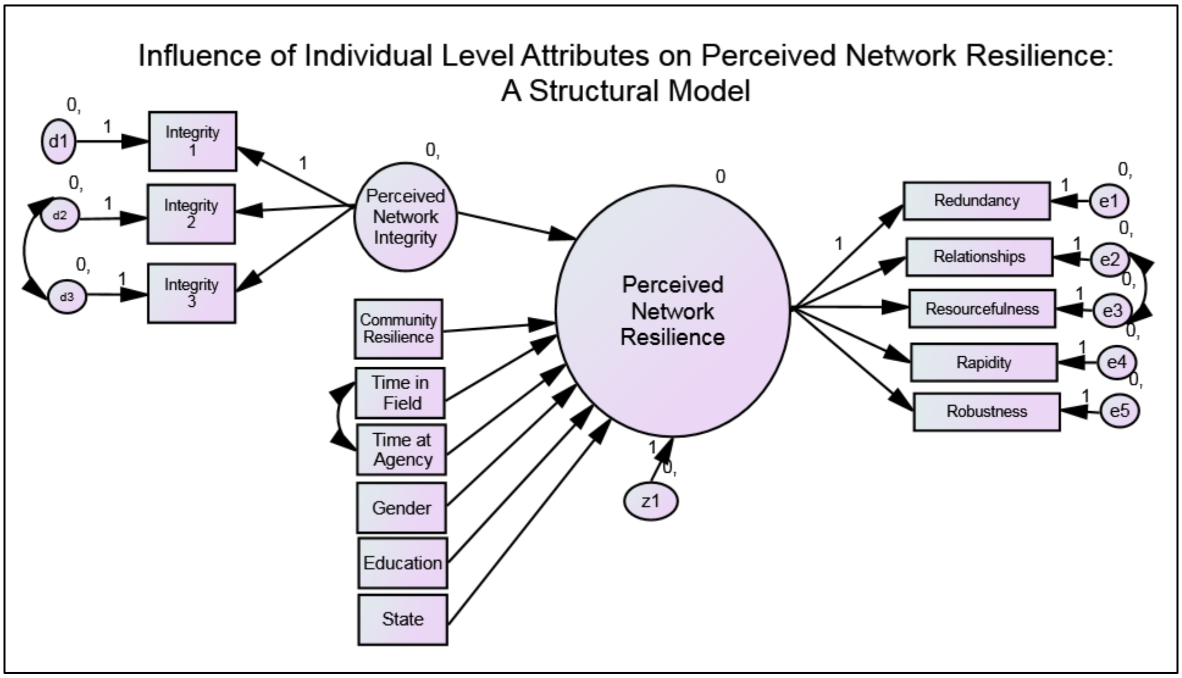


Figure 13. Proposed Structural Model for Influence of Individual Level Attributes on Perception of Network Resilience

The individual level demographic variables of experience, gender, and education were not found to be statistically significant predictors of perception of network resilience. Perception of community resilience and perception of network integrity, however, were demonstrated to be significant predictors of perception of network resilience. Each change of 1 standard deviation in perceived network integrity would increase perception of network resilience by .82. Each change of 1 standard deviation in perceived community resilience would, statistically, increase perception of network resilience by .09. The summary of measurement parameters for this model are presented in Table 10.

Table 10. Summary of Parameter Measurements for Proposed Structural Model for Influence of Individual Level Attributes on Perception of Network Resilience

			Unstandardized Estimate	S.E.	C.R.	P	Standardized Estimate
Perc_NR	<---	Perc_NI	2.439	.681	3.579	***	.820
Perc_NR	<---	com_Resi	.093	.046	2.036	.042	.094
Perc_NR	<---	State_ID	-.003	.005	-.518	.604	-.023
Perc_NR	<---	YRS_Work	.019	.010	1.946	.052	.107
Perc_NR	<---	YRS_Ag	-.008	.015	-.576	.565	-.030
Perc_NR	<---	EDUC	-.020	.057	-.342	.732	-.015
Perc_NR	<---	Gender	-.324	.184	-1.761	.078	-.081
Red_I	<---	Perc_NR	1.000				.457
Relat_I	<---	Perc_NR	2.248	.385	5.833	***	.860
Resou_I	<---	Perc_NR	2.308	.390	5.911	***	.895
Rapid_I	<---	Perc_NR	1.711	.296	5.785	***	.829
INTEG_2	<---	Perc_NI	2.665	.797	3.345	***	.822
INTEG_3	<---	Perc_NI	2.908	.843	3.450	***	1.026
INTEG_1A	<---	Perc_NI	1.000				.330
Robust_I	<---	Perc_NR	1.431	.245	5.852	***	.857

For this model, a χ^2 = 186.728 with 73df, p=.201and χ^2/df = 2.558 did not indicate a significant model fit, which suggests that the proposed model is inconsistent with observed data. Goodness-of-fit indices support that analysis with a CFI=.875, TLI=.820, and RMSEA=.102. Additional model trimming was performed.

Additional model trimming resulted in a structural model for individual level variables with an acceptable fit that included only perception of community resilience and perception of network integrity and a measurement model revision with the removal of the index for robustness (see Figure 14).

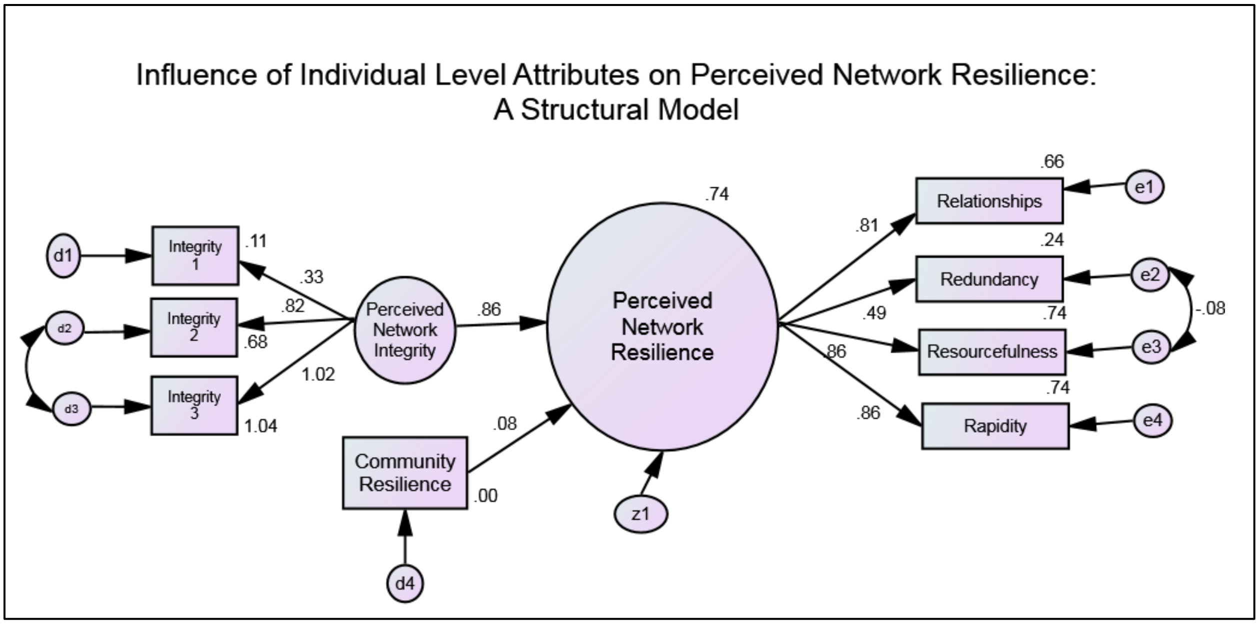


Figure 14. Final Structural Model for Influence of Individual Level Attributes on Perceived Network Resilience

For this model, a χ^2 = 21.185 with 17df, p=.350and χ^2/df = 1.246 did indicate a very good model fit, which suggests that the proposed model is consistent with observed data. Goodness-of-fit indices support that analysis with a CFI=.998, TLI=.995, and RMSEA=.027. A summary of measurement parameters for this final structural model of individual level indicators is in Table 11.

Table 11. Summary of Parameter Estimates for Final Structural Model for Influence of Individual Level Attributes on Perceived Network Resilience

			Unstandardized Estimate	S.E.	C.R.	P	Standardized Estimate
Perc_NR	<---	Perc_NI	5.390	1.259	4.282	***	.856
Perc_NR	<---	COM_RESI	.171	.094	2.217	.046	.082
Red_I	<---	Perc_NR	.498	.083	5.993	***	.486
Resou_I	<---	Perc_NR	1.045	.084	12.391	***	.861
Rapid_I	<---	Perc_NR	.834	.067	12.444	***	.862
INTEG_2	<---	Perc_NI	2.656	.782	3.398	***	.823
INTEG_3	<---	Perc_NI	2.872	.820	3.503	***	1.019
INTEG_1A	<---	Perc_NI	1.000				.332
Relat_I	<---	Perc_NR	1.000				.812

Although five of the original seven proposed individual level indicator variables were not found to have a significant influence on perception of network resilience, the remaining two indicators were found to have a significant influence on perception of network resilience although perception of network integrity demonstrated a much strongest influence than perception of community resilience. Consequently, hypothesis two, that specific individual level indicators can predict perception of emergency management network resilience, is accepted.

Hypothesis 3

Hypothesis 3: Specific state level indicators can predict perception of emergency management network resilience.

State level variables include disaster history, state emergency management budget, full time emergency management employees, state well-being, and FEMA region. According to FEMA data, there were 861 major presidential disaster declarations and 202 emergency presidential disaster declarations between 1995 and 2010. The average number of major declarations per state in that 15 year period was 17, with a range of 4 to 34. The average number of emergency declarations in that same period was 4, with just 1 state seeing no emergency declarations and the rest reporting a range of 1 to 14. The distribution of declarations is illustrated in Table 12.

Table 12. Major and Emergency Presidential Disaster Declarations in the United States, 1995 through 2010

Major Disaster Declarations (1995-2010)	
Number of MDD	**Number of States**
21-34	20 states
10-20	15 states
4-9	16 states
Emergency Disaster Declarations (1995-2010)	
Number of EDD	**Number of States**
10-14	5 states
5-9	11 states
1-4	34 states
0	1 state

Among the 47 states represented in survey responses, the minimum State emergency budget reported to NEMA (2010) was $497,654. The maximum budget reported was $50,707,629 with a mean state emergency management budget of $675,938. The NEMA data accessed for this study illustrated that, on average, state emergency management agency budgets amount to approximately $1.52 per state citizen, with a range $0.12 to $12.94. Of note, only one state demonstrates spending above $5.10 per citizen.

States reported a minimum of 19 full time employees in their state emergency management agencies with a maximum of 518 employees. When taken as a ratio of full time employees to population, the state with the smallest ratio reports one full time employee for every 9,226 state residents. At the other end of the continuum, one state reports one full time employee for every 124,114 residents. Taken as an employee to budget ratio, the smallest ratio reported by one state is one full time employee for every $9,155 of the emergency management budget. The largest ratio reported is one employee for every $332,010 of the state's emergency management budget. Mean for this ratio was $59,622 for every one state employee with a standard deviation of $55,027.

State well-being data from the Social Vulnerability Index and American Human Development Index were evaluated. Higher social vulnerability scores reflect a lower level of well-being and higher risk of experiencing a negative impact from disaster. Social vulnerability index scores ranged from 3.27 to -3.65 with a standard deviation of 1.59 for the 47 states represented by participant survey responses. The mean SoVI score was -.4240, near the median of -.5400. The smallest of multiple modes for SoVi was 0.58.

In contrast, higher American Human Development Index (HDI) scores reflect higher level of well-being. Lower scores reveal an increased risk of experiencing negative disaster related impacts. HDI scores ranged from 3.85 to 6.30 with a standard deviation of .637, a mean of 5.05, median of 5.03, and lowest of multiple modes of 5.53.

Among state level variables, statistically significant relationships included a weak negative correlation between Human Development Index (HDI) score and major presidential disaster declarations (MDD) (r = -.389, n=47, p<.005), with higher HDI scores associated with fewer major disaster declarations. HDI was also found to be moderately negatively associated with Social Vulnerability Index (r= -.589, n=47, p<.000), with higher development index scores associated with lower vulnerability scores. This negative correlation is expected given the inverse scales utilized with the HDI and SoVI.

Correlation results for state level variables is displayed in Appendix H. State population was moderately associated with emergency presidential disaster declarations (*r*=.409, n=51, p<.003), strongly associated with state emergency management budget (*r*=.666, n=51, p<.000) but not with budget per person, and very strongly associated with number of full time state emergency management employees (*r*=.833, n=51, p<.000). State EM budget was also strongly associated with number of full time state emergency management employees (*r*=.586, n=51, p<.000). Increased emergency presidential disaster declarations (ED) were also moderately associated with the number of full time emergency management employees in a state (*r*=.416, n=51, p<.003). These results suggest that states with larger populations have more emergency presidential disaster declarations, and, probably as a result, more full time EM employees and a higher state EM budget.

State-Level Predictors Model

The influence of state level attributes on perception of network resilience was analyzed in a structural equation model (Figure 15). The analytical model for state level attributes included four exogenous variables of state population, state budget for emergency management, number of full time state employees, and FEMA region. Two latent variables for disaster history and state well-being were also included.

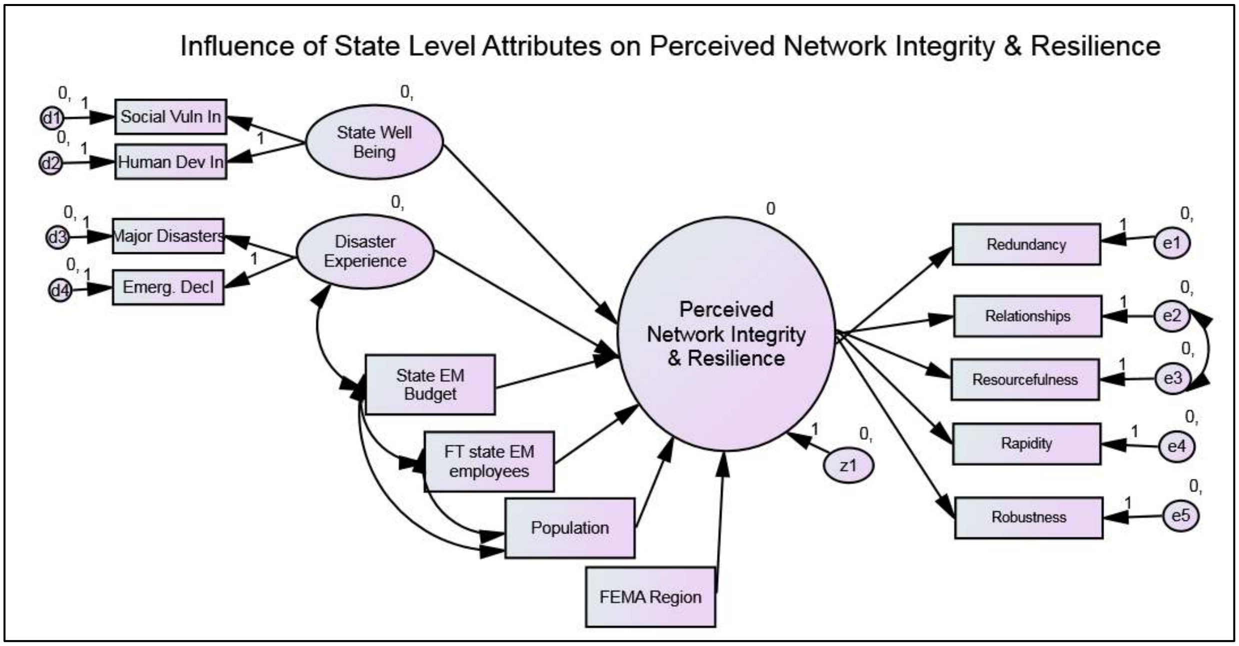


Figure 15. Proposed Structural Model for Influence of State Level Attributes on Perceived Network Resilience

A summary of measurement parameters for the proposed structural model of state level indicators is in Table 13. For this model, a $\chi^2 = 114.48$ with 43df, p=.091 and χ^2/df = 2.66 shows an acceptable fit, which suggests that the proposed model is consistent with observed data. Goodness-of-fit indices support this analysis with a CFI=.923, TLI=.882, and RMSEA=.081.

Table 13. Summary of Parameter Estimates for Proposed Structural Model for Influence of State Level Attributes on Perceived Network Resilience

			Unstandardized Estimate	S.E.	C.R.	P	Standardized Estimate
Perc_NR	<---	BUDGET	.000	.000	-.885	.376	-.111
Perc_NR	<---	FTEmploy	.008	.006	3.465	***	.182
Perc_NR	<---	FEMA_RE	-.173	.208	-.833	.405	-.105
Perc_NR	<---	Popul	.000	.000	1.563	.118	.194
Perc_NR	<---	HDI	-1.979	.877	-2.257	***	-.274
Perc_NR	<---	MDD	-.080	.069	-3.156	***	-.144
Relat_I	<---	Perc_NR	1.000				.924
Resou_I	<---	Perc_NR	1.003	.071	14.113	***	.937
Rapid_I	<---	Perc_NR	.675	.054	12.558	***	.795
Red_I	<---	Perc_NR	.411	.066	6.181	***	.468
Robust_I	<---	Perc_NR	.588	.041	14.204	***	.853

The predictor variables of state budget, state population and FEMA region were not found to have any statistically significant influence on perception of network resilience. Model adjustments were made to achieve the final structural model for state level attributes that influence perception of network resilience in Figure 16.

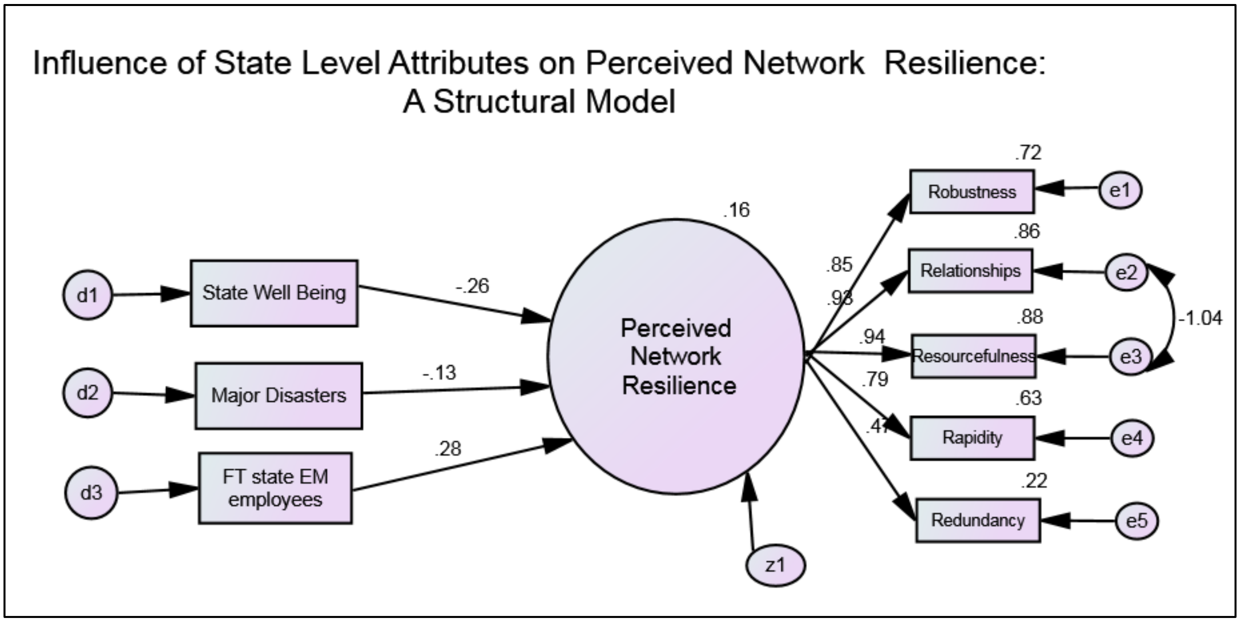


Figure 16. Final Structural Model for Influence of State Level Attributes on Perceived Network Resilience

Noteworthy features of this model include the negative relationships between perception of disaster resilience and both state well-being and disaster experience and the positive relationship between number of full time emergency management employees and perception of network resilience as illustrated by the statistically significant standardized regression coefficients. A summary of measurement parameters for the final structural model of state level indicators is in Table 14. The standardized coefficients reveal the strongest relationship between state well-being and perception of network resilience. Due to a previous data transformation of the indicator for state well-being (Human Development Index), this relationship is not actually negative and should be interpreted to suggest that the better a state's well-being, the more resilient a state emergency management network is perceived to be. In contrast, results suggest that the more disaster experience a state has, the lower the network resilience.

Table 14. Summary of Parameter Measurements for Final Structural Model for Influence of State Level Attributes on Perceived Network Resilience

			Unstandardized Estimate	S.E.	C.R.	P	Standardized Estimate
Perc_NR	<---	FTEmploy	.013	.005	2.309	***	.284
Perc_NR	<---	HDI	-1.842	.894	-2.061	***	-.255
Perc_NR	<---	MDD	-.071	.070	-3.013	***	-.129
Relat_I	<---	Perc_NR	1.000				.925
Resou_I	<---	Perc_NR	1.002	.071	14.084	***	.937
Rapid_I	<---	Perc_NR	.674	.054	12.507	***	.793
Red_I	<---	Perc_NR	.410	.066	6.167	***	.467
Robust_I	<---	Perc_NR	.586	.041	14.148	***	.851

Although three of the original six proposed indicator variables were not found to have a significant influence on perception of network resilience, the remaining three indicators were found to have a significant influence on perception network resilience. Consequently, hypothesis three, that specific state level indicators can predict perception of emergency management network resilience, is accepted.

Hypothesis 4

Hypothesis 4: State level variables are more influential than individual level variables in explaining the variability in perceived emergency network resilience.

A structural model was tested to explore relationships between the individual and state level attributes previously identified as having a significant influence on perception of network resilience (see Figure 17).

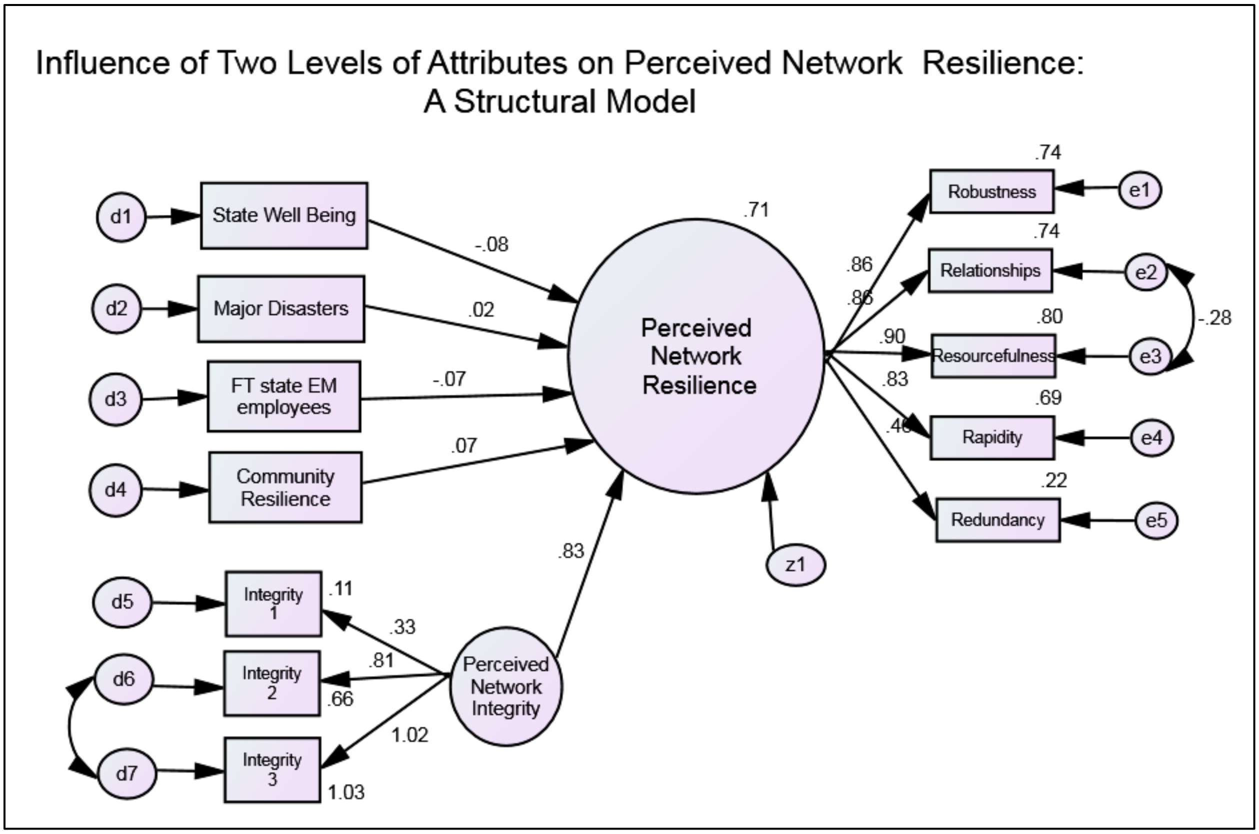


Figure 17. Final Structural Model for Two Levels of Attributes on Perception of Network Resilience

In this model, the attribute with the strongest influence on perception of network resilience is perception of network integrity. Additional statistically significant relationships in this model include state well-being, major disasters, number of full time state employees and perception of community resilience. A summary of measurement parameters for this final structural model with two levels of indicators is in Table 15.

For this model, a $\chi^2 = 79.08$ with 41df, p=.179 and χ^2/df = 1.949 did indicate a very good model fit, which suggests that the proposed model is consistent with observed data. Goodness-of-fit indices support that analysis with a CFI=.950, TLI=.920, and RMSEA=.049.

Table 15. Summary of Parameter Measurements for Final Two-Level Structural Equation Model

			Unstandardized Estimate	S.E.	C.R.	P	Standardized Estimate
Perc_NR	<---	MDD	.012	.037	2.330	***	.025
Perc_NR	<---	Perc_NI	5.553	1.288	4.312	***	.834
Perc_NR	<---	FTEmploy	-.003	.003	-2.892	***	-.066
Perc_NR	<---	HDI	-.548	.479	-3.145	***	-.084
Perc_NR	<---	Com_RESI	.165	.099	6.669	***	.074
Relat_I	<---	Perc_NR	1.000				.861
Resou_I	<---	Perc_NR	1.027	.077	13.334	***	.896
Rapid_I	<---	Perc_NR	.760	.059	12.878	***	.829
Red_I	<---	Perc_NR	.449	.076	5.940	***	.465
Robust_I	<---	Perc_NR	.637	.047	13.685	***	.859
INTEG_2	<---	Perc_NI	2.603	.764	3.407	***	.811
INTEG_3	<---	Perc_NI	2.850	.810	3.521	***	1.016
INTEG_1A	<---	Perc_NI	1.000				.334

Perception of network integrity demonstrates the strongest relationship with perception of network resilience with a standardized estimate of .834, indicating that for every one unit of increase in perception of network resilience, perception of network integrity increases by .834, as demonstrated in Figure 17. Other attributes demonstrated weaker influence on perception of network resilience, with perception of community resilience explaining the most remaining variance in perception of network resilience at 27% as illustrated in Table 16.

Table 16. Squared Multiple Correlations of Two Levels of Indicators of Perception of Network Resilience

	Estimate
Com_RESI	.269
FTEmploy	.091
MDD	.137
HDI	.204

As perception of network integrity is an individual level attribute, the hypothesis that state level variables are more influential than individual level variables in explaining the variability in perceived emergency network resilience is not supported by the data.

CHAPTER FIVE: DISCUSSION

This research attempted to identify attributes that influence state emergency management network resilience. Three of the four research hypotheses were supported.

This chapter presents a summary of study findings in Table 17. Theoretical, methodological, practical and policy implications of the study are discussed. Limitations and significant contributions are summarized. Finally, suggestions for future research and conclusions are offered.

Table 17. Findings from Results Testing of Study Hypotheses

Hypotheses	**Proposed Predictor Variables**	**Significant Variables**
H1: Network resilience is validly measured by the constructs of redundancy, rapidity, resourcefulness, robustness, and relationships.	1. Rapidity Indicators 2. Redundancy Indicators 3. Relationship Indicators 4. Resourcefulness Indicators 5. Robustness Indicators	1. Rapidity Index 2. Redundancy Index 3. Relationship Index 4. Resourcefulness Index 5. Robustness Index
H2: Specific individual level indicators can predict perception of emergency management network resilience.	1. Years employed in Emergency Management 2. Years employed at current state agency 3. Gender 4. Educational Attainment 5. Perception of Network Integrity 6. Perception of Community Resilience	1. Perception of Network Integrity 2. Perception of Community Resilience
H3: Specific state level indicators can predict perception of emergency management network resilience.	1. State Disaster Experience 2. State Well-Being 3. State Emergency Management Budget 4. State Population 5. Full-time State Emergency Management Employees 6. FEMA Region	1. State Disaster Experience 2. State Well-Being 3. Full-time State Emergency Management Employees
H4: State-level variables are more influential than individual-level variables in explaining the variability in perceived emergency network resilience	1. Years employed in Emergency Management 2. Years employed at current state agency 3. Gender 4. Educational Attainment 5. Perception of Network Integrity 6. Perception of Community Resilience 7. State Disaster Experience 8. State Well-Being 9. State Emergency Management Budget 10. State Population 11. Full-time State Emergency Management Employees 12. FEMA Region	1. Perception of Network Integrity 2. Perception of Community Resilience 3. State Disaster Experience 4. State Well-Being 5. Full-time State Emergency Management Employees

Hypothesis 1

Hypothesis 1 stated: Network resilience is validly measured by the constructs of redundancy, rapidity, resourcefulness, robustness, and relationships.

The measurement model for network resilience included five constructs conceptualized to reflect the capacity of a network of emergency management partners to support exchange of resources and information. The model was found to be valid, with, in descending strength, the constructs of resourcefulness, relationships, robustness, rapidity, and redundancy validly and reliably measuring perception of network resilience so this hypothesis was accepted.

With a valid measurement model, two levels of attributes believed to influence perception of network resilience were identified.

Hypothesis 2

Hypothesis 2 stated: Specific individual level indicators can predict perception of emergency management network resilience.

Two individual level attributes demonstrated a statistically significant influence on perception of network resilience; perception of community resilience and perception of network integrity, so Hypothesis 2 was accepted. Variables in the latent construct of network integrity were identified by the researcher based on the theoretical frameworks guiding the study. The measurement model for perception of network integrity was also determined to be valid, suggesting that measures of community insulation, distributional equity of decision making power, and preparedness to collaborate can be considered measures of network integrity. Perception of network integrity demonstrated a stronger relationship with perception of network resilience than did perception of community resilience, perhaps in part because respondents held a range of definitions of community resilience despite being given a specific definition to consider. The three variables in the construct of network integrity were less conceptually abstract than community resilience, which may also have influenced respondent perceptions.

Qualitative responses indicated many different perceptions of community resilience regardless of that definition, so results may have been influenced if participants considered a different definition of community resilience when responding. This possibility is reinforced by the lack of correlation in this study between respondent perception of community resilience in their home state and both the HDI and SoVI, two indicators of state well-being.

Hypothesis 3

Hypothesis 3 stated: Specific state level indicators can predict perception of emergency management network resilience.

Three state level attributes were found to be statistically significant predictors of perception of network resilience so Hypothesis 3 was accepted. Two of those, number of full time employees and disaster experience, may influence the frequency and breadth of opportunities for network partners to participate in resource and information exchange. The number of full time employees was found to weakly influence perception of network resilience, perhaps because the more employees a state emergency management agency has, the fewer relationships with other entities each might develop as job duties are spread across more staff. This importance of this finding is reinforced by proceedings of a 2014 workshop series on regional disaster response coordination to support health outcomes convened by the Institute of Medicine. A summary of expert attendee opinions suggests that the most significant challenge to cross-sector collaboration during disaster is sustainability of collaborations during "peace time"

(Institute of Medicine [IOM], 2015b). Federal funding decreases have left public agencies with fewer staff to maintain public-private partnerships. Disaster experience was found to weakly influence perception of network resilience perhaps in part because measurement for that construct is only based on one indicator, major presidential disaster declarations. This type of disaster declaration is based on estimated economic loss, so a disaster with very high economic impact over a short time period and requiring few resources may qualify, even if there is not a correlated large scale network response with extended need for resource and information exchange.

The third state-level attribute, state well-being, was weakly related, suggesting that changes in state well-being have slight influence on perception of network resilience. While the theoretical framework for this study supported overall community well-being as a predictor of resilience, there may not be a direct relationship between community resilience and network resilience.

Hypothesis 4

Hypothesis 4 stated: State-level variables are more influential than individual-level variables in explaining the variability in perceived emergency network resilience.

State level attributes were in fact found to have less influence on perception of network resilience than either of the two statistically significant individual level variables, perception of network integrity and perception of community resilience. Hypothesis 4 is not accepted.

Implications of the Study

Theoretical Implications

This research supports the premise that state emergency management networks can be viewed as both communities and complex adaptive systems and as such, can experience improved resilience when developed according to those respective states. The valid addition of relationships as a fifth construct to the MCEER 4 R's of Resiliency scale may warrant further investigation for network level study. The influence of network integrity on network resilience illustrated in this study may suggest there is value in consideration of network integrity as an antecedent to network resilience. The construct of network integrity, as conceptualized in this study, reflects a measure of current readiness to collaborate and two measures of a structural framework to guide collaboration. Finally, this study is evidence that continued research efforts to define resilience in the context of networks, communities, and vulnerability are necessary.

Methodological Implications

This study reinforces the need to collect better data at the state level. Common measures of state well-being are very difficult to compare due to sample and analysis constraints. It also illustrates the challenges inherent to relying on one network entity to provide data about perceptions of resilience across the entire network. Obtaining an adequate sample size was difficult despite drawing from one of the few entities that participates in every state emergency management network. While more diverse perspectives could provide a more comprehensive perspective on network resilience, sample identification and data collection would be cumbersome. The construct for network integrity could be evaluated as a state level attribute if appropriate measures for the indicators could be identified.

Practical Implications

The identification of attributes that influence emergency management network resilience could have tremendous impact on the ability of state emergency management agencies to guide their own networks to perform more vigorous resilience assessments. The clear relationship between perception of network integrity and perception of network resilience suggests that networks should work to improve their integrity by increasing communication and relationship building with local entities to decrease their insulation from communities. They should also ensure that economic and policy decision making power is equitably distributed across the network and test preparedness to mount a collaborative response.

Networks that work to improve perception of network integrity should find agency employees reporting increased perception of network resilience, reflecting an increased trust in exchange relationships. Indirect but still practical benefits may include less uncertainty and decreased employee/participant stress during an actual disaster/emergency if their state network responds more efficiently and/or effectively as a result of improved preparation and network development. The lack of variability in the state-level predictors in this study contributes to the weaker explanatory power in the prediction of perceived emergency network resiliency.

Policy Implications

Several policy implications arise from this study. Most significant relates to the finding that perception of network integrity has a significant and strong influence on perception of network resilience. Policy makers and funding entities should encourage and fund network resilience building activities that reflect a commitment to build network integrity. Network integrity could be considered evidence of a robust complex adaptive system, one that can affect the necessary structural adaptation to improve efficiency and effectiveness during disaster response.

While number of full time employees is weakly associated with increased perception of network resilience, study findings do not have adequate strength to support adjustment of staffing models as a technique to improve perception of network resilience. Similarly, state well-being is a dynamic and fluid construct. Although the relationship between state well-being and perception of network resilience is weak, it is still significant. Entities involved in developing community well-being can rest assured their work will continue to inform network resilience.

Finally, given the weak but significant relationship between disaster history and perception of community resilience, state emergency management agency representatives and federal partners may consider emphasizing the value of after-action reports and corrective action plans to increase the chance networks will identify opportunities to develop relationships of resource and information exchange.

Limitations of the Study

Several study limitations should be noted. One limitation of this study was consideration of only employees from each state emergency management agency to participate in a survey designed to assess network relationships between a number of different entities. It is possible that state emergency management agency employees may have some inherent bias related to the relative position of their agency in most networks or they may have limited or inaccurate information relative to the real levels of involvement, functions or capacities of other agencies.

Another limitation was the irregular representation of states in the study sample. The sampling goal was to have a minimum of four surveys from each state to ensure adequate comparability. In fact, more than four surveys were received from only 17 states. It is possible that this variability could weight responses at the individual attribute level if same-state respondents shared common perceptions due to variables not measured by this study. No significant differences were seen in results when controlling for state but the sample inconsistency may have diminished the power of the statistical tests to identify any difference. For this reason, state averages for individual level attributes were also not reported.

This research surveyed employee perception at just one point in time without regard to current disaster response status, another limitation of the study. Although some respondents reported being in the middle of response activity during survey participation, the presence or absence of an emergency state was not collected. It is possible that perception of network resilience is not only influenced by disaster history, as conceptualized, but also by current disaster status. A comparison of perception of network resilience during both disaster and non-disaster times would address this limitation.

Finally, it is important to note that while findings are reflective of a sample drawn from 47 states, results should not be considered generalizable without additional analysis of state-specific network structure, resources, priorities and experience. Significant structural differences in state governance, budget strategy, emergency management agency administrative structure and culture, and types of agencies and organizations that populate each state emergency management network were not evaluated so limited direct comparison can be made.

Contributions of the Study

This study demonstrated a valid measurement model for perception of network resilience. It also identified attributes at the state and individual level that influence perception of network resilience. As an indicator of capacity to adapt to the negative impacts of disaster and recover services and support to baseline pre-event levels, network resilience is a valuable measure. LaFond, Brown, and Macintyre suggest that achieving better [health] outcomes requires both increased financial investment and adequate local capacity to use resources effectively (2002). This study is positioned to contribute to the body of knowledge that guides policy development, investment and resource allocation to build emergency management network resilience. Study findings reinforce the premise that there are structural and organizational characteristics of networks, identified here as network integrity, that can be developed to increase perception of network resilience. Identification of state attributes that also influence network resilience like disaster experience, number of full time employees, and state well-being can reinforce the value of increased investment in network development activity across all four of the emergency management cycles of mitigation, preparedness, response and recovery.

Recommendations

A number of recommendations for future research arose from this study. One of the more significant would be network analysis of multiple state emergency management networks to determine if perception of network resilience is related to specific network analysis measures like centrality or cliques and if so, if network maps might be an acceptable proxy for network resilience. A follow-on study to that would be longitudinal network analysis to determine if network entities change position and roles to exchange resources and information differently during a disaster than they do when there is not an event and if so, how. Those organic strategies that networks develop to function during periods of stress may be innovative best practices worth replicating or they may have a negative impact on network integrity and ultimately, resilience.

Simulation could be a solution to the current organizational and management challenges inherent in static network analysis. Replication of network relationships and attributes that influence them could allow model simulation to further explore how network development activities may influence network form, function, integrity and resilience. Comparison of common attributes of network resilience across state emergency management networks during different phases of network development may expand understanding of and of different types of networks.

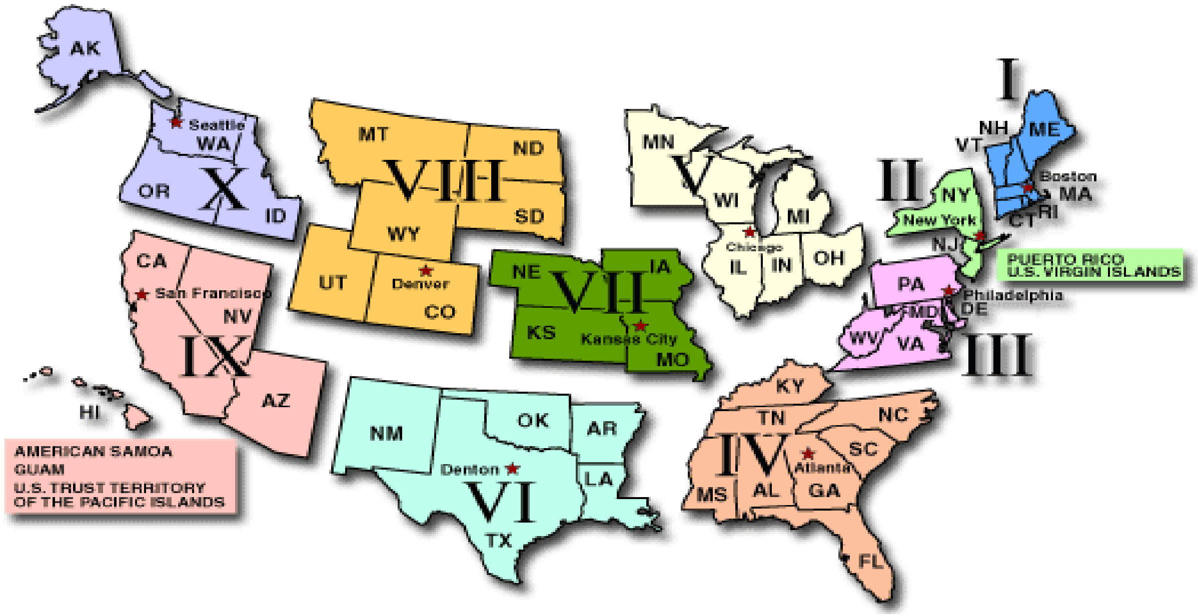
If states with more disaster experience do in fact demonstrate more resilient emergency management networks, a logical next step would be a network analysis of all state emergency management networks in an effort to determine what similarities in network structure might be present among more disaster experienced networks and/or lacking in those networks with less experience so that purposeful network development can be undertaken to adapt the network structure to better resemble that of a more resilient network.

Conclusion

When any relationship includes the exchange of resources or information, trust is generated. When networked actors participate in that exchange, that trust is perceived as network resilience. Study results support the premise that network resilience can be increased by development of a network framework that supports exchange of resources and information within those relationships. That framework, conceptualized in this study as network integrity, encourages equitable distribution of decision making power, increased readiness to collaborate and decreased insulation from communities as important indicators of perception of network resilience. State emergency management agencies are strongly anchored institutions in each state emergency management network. This position allows a more loosely structured and flexible network to develop around them (National Academies, 2013). That flexibility, once again, contributes to both the adaptability and sustainability of the network, both important attributes of a functional emergency management network with the capacity to influence disaster impacts.

Increased network resilience means the network's capacity to facilitate resource and information exchange during emergencies is less vulnerable to disruption and failure. A community's resilience to disaster depends in part on the resilience of the network that is charged with leading disaster mitigation, preparedness, response and recovery efforts. As both the first responders, and sometimes the only responders, with the tools and technical expertise to support disaster victims, emergency management networks should do all they can to maintain their network's integrity during non-disaster periods to improve their resilience, protect their capacity to function during disaster and contribute to community resilience.

APPENDIX A: MAP OF STATES BY FEMA REGION



Source: FEMA Regional Contact Information @ https://www.fema.gov/regional-contact-information

APPENDIX B: PERCEPTION OF NETWORK RESILIENCE SURVEY QUESTIONS

Construct: Robustness

Not Very Connected				Somewhat Connected				Very Connected
1	2	3	4	5	6	7	8	9

RO_1: How connected do you think member organizations are with each other within your state emergency management (EM) network?

RO_4: How connected do you think your state (EM) agency is with other member organizations in your state (EM) network?

Subtract Many		Subtract Some		Do Nothing		Add Some		Add Many
1	2	3	4	5	6	7	8	9

RO_2: Please indicate how you would adjust the number of member agencies/organizations in your state (EM) network to make your network as strong as possible.

Lowest Level				Moderate Level				Highest Level
1	2	3	4	5	6	7	8	9

RO_3: At which level of stress do you believe your state (EM) network would begin to suffer a loss of performance and function?

Construct: Resourcefulness

Not Confident At All				Somewhat Confident				Very Confident
1	2	3	4	5	6	7	8	9

RE_4: How confident are you in the ability of member organizations in your state (EM) network to identify and address collective problems related to (EM)?

RE_1: How confident are you in the ability of member organizations in your state (EM) network to establish collaborative (EM) priorities?

RE_2: How confident are you in the ability of member organizations in your state (EM) network to mobilize (EM) resources like personnel, equipment, and information?

RE_3: How confident are you in the ability of the member organizations in your state (EM) network to efficiently exchange (EM) resources like personnel, equipment, and information?

Construct: Redundancy

Not At All Likely				Somewhat Likely				Very Likely
1	2	3	4	5	6	7	8	9

RD_2: What is the likelihood that at least one other member organization in your state (EM) network could perform the work of another member organization if that original organization fails when there is **no emergency**?

RD_5: What is the likelihood that at least one other member organization in your state (EM) network could perform the work of another member organization if that original organization fails **during an emergency** response?

Not At All Often				Somewhat Often				Very Often
1	2	3	4	5	6	7	8	9

RD_1: How often do two or more member organizations in your state (EM) network perform the same role or function **during an emergency** response?

RD_3: How often do two or more member organizations in your state (EM) network perform the same role or function when there is **no emergency**?

RD_4: How often do member organizations in your state (EM) network share resources like personnel, equipment or supplies **during an emergency** response?

RD_6: How often do member organizations in your state (EM) network share resources like personnel, equipment or supplies when there is **no emergency**?

Construct: Rapidity

Not At All Quickly				Somewhat Quickly				Very Quickly
1	2	3	4	5	6	7	8	9

RA-1: **During an emergency**, how quickly can you expect MOST organizations in your state (EM) network to respond to any request from your agency?

RA-2: **During an emergency**, how quickly can you expect MOST organizations in your state (EM) network to mobilize and fulfill their responsibilities?

RA-3: When there is **no emergency**, how quickly can you expect MOST organizations in your state (EM) network to mobilize and fulfill their responsibilities?

RA-4: When there is **no emergency**, how quickly can you expect MOST organizations in your state (EM) network to respond to any request from your agency?

Construct: Relationships

Not At All Strong				Somewhat Strong			Very Strong	
1	2	3	4	5	6	7	8	9

FEMA_FED: How would you describe the strength of the relationship between your state (EM) agency and the federal FEMA office?

FEMA_ST: How would you describe the strength of the relationship between your state (EM) agency and your regional FEMA office?

INTER_ST: How would you describe the strength of the relationship between your state (EM) agency and (EM) agencies in other states?

NETWORK: How would you describe the strength of the emergency management network in your state?

LOCAL: How would you describe the strength of relationships between your state (EM) agency and local governments in your state?

STATE: How would you describe the strength of relationships between your state (EM) agency and other agencies in your state (EM) network?

Construct: Network Integrity

Not At All Insulated			Somewhat Insulated				Very Insulated	
1	2	3	4	5	6	7	8	9

Integ_1: How insulated do you thing members of your entire state (EM) network are from the communities they serve?

Not At All Fairly			Somewhat Fairly				Very Fairly	
1	2	3	4	5	6	7	8	9

Integ_2: Consider the entire network of emergency management actors in your state; how fairly and equitably is the power to make economic and policy decisions distributed across that network??

Not Well Prepared			Somewhat Well Prepared				Very Well Prepared	
1	2	3	4	5	6	7	8	9

Integ_3: How well prepared do you think the entire emergency management network in your state is right now to respond collaboratively to an emergency or disaster?

Community Resilience

Please consider the following definition of community resilience:

Community resilience is the ability of a community to respond with strength in the face of adversity, and in so doing reach a higher level of function in recovery.

Not At All Resilient				Somewhat Resilient				Very Resilient
1	2	3	4	5	6	7	8	9

21. When applying the definition of community resilience given above, how resilient do you think the communities in your home state are to disaster today?

APPENDIX C: US COUNTY-LEVEL 2006-2010 SOCIAL VULNERABILITY COMPONENT SUMMARY

Component	*Cardinality*	*Name*	*% Variance Explained*	*Dominant Variables*	*Component Loading*
1	+	Race (Black) and Class (Poverty)	16.599	QFHH	0.863
				QBLACK	0.752
				QPOVTY	0.715
				QNOAUTO	0.615
				QCVLUN	0.612
				QED12LES	0.547
				QFAM	-0.837
2	-	Wealth	15.905	MEHSEVAL	0.891
				QRICH200K	0.854
				MDGRENT	0.85
				PERCAP	0.805
				QASIAN	0.681
3	+	Age (Old)	13.196	MEDAGE	0.889
				QAGEDEP	0.767
				QSSBEN	0.763
				QUNOCCHU	0.718
				PPUNIT	-0.596
				QRENTER	-0.669
4	+	Ethnicity (Hispanic)	9.479	QNOHLTH	0.744
				QHISP	0.725
				QEXTRCT	0.545
				QED12LES	0.532
				QFEMLBR	-0.621
5	+	Nursing Home Residents	7.471	QNRRES	0.666
				HOSPTPC	0.643
6	+	Ethnicity (Native American)	5.042	QNATAM	0.892
7	+	Employment in Service Industries	4.809	QSERV	0.739
				QFHH	-0.660
	Cumulative Variance Explained		**72.501**		

Notes**:**

- Component scores/composite SoVI scores are relative and comparable across the U.S.
- The SoVI composite score is obtained by summing all component scores.

Source: Hazards & Vulnerability Research Institute @ University of South Carolina
http://webra.cas.sc.edu/hvri/products/sovi.aspx

APPENDIX D: SOCIAL VULNERABILITY INDEX AND HUMAN DEVELOPMENT INDEX SCORES BY STATE

State	HDI	HDI_I*	SoVI
Alabama	4.09	-2.21	-0.72657351
Alaska	5.27	-1.03	2.02013745
Arizona	5.11	-1.19	1.69310173
Arkansas	3.87	-2.43	0.71847649
California	5.56	-0.74	-1.30347271
Colorado	5.65	-0.65	-0.64848181
Connecticut	6.30	0.00	-3.64616475
Delaware	5.33	-0.97	-2.61936400
Florida	5.07	-1.23	0.53623704
Georgia	4.86	-1.44	-0.52423931
Hawaii	5.73	-0.57	-1.09131960
Idaho	4.65	-1.65	-0.54086464
Illinois	5.39	-0.91	-0.61278150
Indiana	4.74	-1.56	-1.40057096
Iowa	5.06	-1.24	0.23639557
Kansas	5.06	-1.24	0.53776021
Kentucky	4.23	-2.07	0.10337505
Louisiana	4.07	-2.23	0.39679835
Maine	4.89	-1.41	-0.57687244
Maryland	5.96	-0.34	-3.42236483
Massachusetts	6.24	-0.06	-3.15886950
Michigan	4.99	-1.31	0.27300664
Minnesota	5.74	-0.56	-0.54273141
Mississippi	3.93	-2.37	0.28741946
Missouri	4.68	-1.62	0.40095794
Montana	4.49	-1.81	3.26584539
Nebraska	5.05	-1.25	1.78118365
Nevada	4.78	-1.52	0.78927006
New Hampshire	5.73	-0.57	-2.50358260
New Jersey	6.16	-0.14	-3.49600519
New Mexico	4.56	-1.74	2.61670209
New York	5.77	-0.53	-0.55946656
North Carolina	4.64	-1.66	-0.62231848
North Dakota	4.92	-1.38	1.50421147
Ohio	4.87	-1.43	-1.11041284
Oklahoma	4.15	-2.15	1.26132675
Oregon	5.03	-1.27	0.30926758
Pennsylvania	5.12	-1.18	-0.78455407
Rhode Island	5.56	-0.74	-2.83654080
South Carolina	4.36	-1.94	-0.50670380
South Dakota	4.82	-1.48	1.92910511
Tennessee	4.33	-1.97	-0.51844360
Texas	4.67	-1.63	1.14287723
Utah	5.08	-1.22	-2.26286448

Vermont	5.27	-1.03	-1.90703857
Virginia	5.53	-0.77	-1.40598119
Washington	5.53	-0.77	-0.58136141
Washington D.C.	6.21	-0.09	-0.25735300
West Virginia	3.85	-2.45	1.16275324
Wisconsin	5.23	-1.07	-1.15976256
Wyoming	4.80	-1.50	-0.92658539

*HDI_I was transformed from HDI to reflect the same directional scale as SoVI.

APPENDIX E: DESCRIPTIVE STATISTICS FOR PERCEPTION OF NETWORK RESILIENCE SURVEY VARIABLES

	N	Range	Minimum	Maximum	Mean	Std. Deviation
State_ID	151	50	1	51	26.85	14.668
YRS_Work	151	45	1	45	13.21	9.945
YRS_Ag	151	33	1	33	8.58	6.442
Gender	151	1	1	1	.73	.446
Educ	151	6	1	7	3.77	1.378
RO_1	151	8	1	9	6.52	1.754
RO_2	151	6	1	7	3.56	.861
RO_3	151	8	1	9	6.91	1.930
RO_4	151	8	1	9	7.13	1.656
NETWORK	151	7	2	9	6.90	1.708
STATE	151	8	1	9	6.97	1.627
FEMA_DIS	151	8	1	9	7.27	1.751
FEMA_FED	151	8	1	9	6.14	2.139
INTER_ST	151	8	1	9	6.12	1.811
LOCAL	151	8	1	9	6.77	1.577
RA_1	151	7	2	9	7.38	1.632
RA_2	151	7	2	9	7.23	1.497
RA_3	151	8	1	9	6.09	1.826
RA_4	151	8	1	9	5.94	1.650
RD_1	151	8	1	9	4.25	2.027
RD_2	151	8	1	9	5.37	1.975
RD_3	151	8	1	9	4.07	2.116
RD_4	151	8	1	9	7.15	1.962
RD_5	151	8	1	9	6.13	1.760
RD_6	151	8	1	9	4.79	2.077
RE_1	151	8	1	9	7.07	1.731
RE_2	151	8	1	9	7.50	1.632
RE_3	151	8	1	9	6.92	1.867
RE_4	151	8	1	9	6.85	1.924
COM_RESI	151	8	1	9	5.63	1.821
Integ_1A	151	8	1	8	5.65	1.830
INTEG_2	151	8	1	9	5.31	1.960
INTEG_3	151	8	1	9	6.99	1.713

APPENDIX F: DESCRIPTIVE STATISTICS FOR PERCEPTION OF NETWORK RESILIENCE SURVEY CONSTRUCTS

Skewedness and Kurtosis of the Perception of Network Resilience Survey Variables

	YRS_ Work	*YRS_Ag*	*Gender*	*Educ*	*COM_ RESI*	*INTEG_1A*	*INTEG_2*	*INTEG_3*	*Red_I*	Relat_I	Resou_I	Rapid_I	Robust_I
Valid N	*151*	*151*	*151*	*151*	*151*	*151*	*151*	*151*	*151*	151	151	151	151
Skewedness	0.704	0.629	0.942	0.163	0.088	0.584	-0.219	-0.88	-0.109	-0.776	0.815	-0.732	-0.401
SE of Skew	0.297	0.297	0.297	0.297	0.297	0.297	0.297	0.297	0.297	0.297	0.297	0.297	0.297
z-score	2.37	2.12	3.17	0.55	0.30	1.97	-0.74	-2.96	-0.37	-2.61	2.74	-2.46	-1.35
Kurtosis	0.521	0.847	-0.936	-0.508	-0.246	0.588	-0.114	0.921	0.169	0.875	0.875	0.394	1.026
SE of Kurtosis	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392	0.392
z-score	1.32	2.16	-2.39	-1.3	-.63	1.50	-0.29	2.35	0.43	2.23	2.23	1.01	2.62

APPENDIX G: CORRELATION TABLE FOR INDIVIDUAL LEVEL ATTRIBUTES

		YRS_Work	YRS_Ag	Gender	Educ	COM_RESI	Integ_1A	INTEG_2	INTEG_3	Red _I	Relat_I	Resou_I	Rapid_I	Robust_I
YRS_Wkk	*Pearson*	1	.540**	.103	-.081	.007	.127	.015	-.006	-.069	.108	.076	-.003	.065
	Sig. (2-tailed)		.000	.209	.325	.934	.121	.853	.937	.398	.188	.356	.975	.427
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
YRS_Ag	*Pearson*	.540**	1	-.061	-.052	.070	.116	.111	.035	-.085	.098	.081	-.009	.123
	Sig. (2-tailed)	.000		.460	.524	.395	.157	.176	.668	.302	.233	.323	.909	.133
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
Gender	*Pearson*	.103	-.061	1	-.038	.089	.136	.113	.048	.067	.017	.015	-.045	-.044
	Sig. (2-tailed)	.209	.460		.643	.279	.097	.169	.562	.413	.834	.855	.582	.594
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
Educ	*Pearson*	-.081	-.052	-.038	1	.029	.028	-.022	-.114	.104	-.077	-.082	-.070	-.161*
	Sig. (2-tailed)	.325	.524	.643		.721	.730	.784	.162	.202	.348	.315	.390	.049
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
COM_RESI	*Pearson*	.007	.070	.089	.029	1	.309**	.490**	.593**	.386**	.501**	.529**	.512**	.504**
	Sig. (2-tailed)	.934	.395	.279	.721		.000	.000	.000	.000	.000	.000	.000	.000
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
Integ_1A	*Pearson*	.127	.116	.136	.028	.309**	1	.287**	.332**	.086	.174*	.318**	.262**	.239**
	Sig. (2-tailed)	.121	.157	.097	.730	.000		.000	.000	.296	.033	.000	.001	.003
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
INTEG_2	*Pearson*	.015	.111	.113	-.022	.490**	.287**	1	.595**	.327**	.535**	.626**	.656**	.572**
	Sig. (2-tailed)	.853	.176	.169	.784	.000	.000		.000	.000	.000	.000	.000	.000
	N	151	151	151	151	151	151	151	151	151	151	151	151	151

		YRS_Work	YRS_Ag	Gender	Educ	COM_RESI	Integ_1A	INTEG_2	INTEG_3	Red_I	Relat_I	Resou_I	Rapid_I	Robust_I
INTEG_3	*Pearson*	-.006	.035	.048	-.114	.593**	.332**	.595**	1	.424**	.723**	.777**	.768**	.729**
	Sig. (2-tailed)	.937	.668	.562	.162	.000	.000	.000		.000	.000	.000	.000	.000
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
Red_I	*Pearson*	-.069	-.085	.067	.104	.386**	.086	.327**	.424**	1	.460**	.403**	.425**	.345**
	Sig. (2-tailed)	.398	.302	.413	.202	.000	.296	.000	.000		.000	.000	.000	.000
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
Relat_I	*Pearson*	.108	.098	.017	-.077	.501**	.174*	.535**	.723**	.460**	1	.724**	.725**	.781**
	Sig. (2-tailed)	.188	.233	.834	.348	.000	.033	.000	.000	.000		.000	.000	.000
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
Resou_I	*Pearson*	.076	.081	.015	-.082	.529**	.318**	.626**	.777**	.403**	.724**	1	.744**	.796**
	Sig. (2-tailed)	.356	.323	.855	.315	.000	.000	.000	.000	.000	.000		.000	.000
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
Rapid_I	*Pearson*	-.003	-.009	-.045	-.070	.512**	.262**	.656**	.768**	.425**	.725**	.744**	1	.676**
	Sig. (2-tailed)	.975	.909	.582	.390	.000	.001	.000	.000	.000	.000	.000		.000
	N	151	151	151	151	151	151	151	151	151	151	151	151	151
Robust_I	*Pearson*	.065	.123	-.044	-.161*	.504**	.239**	.572**	.729**	.345**	.781**	.796**	.676**	1
	Sig. (2-tailed)	.427	.133	.594	.049	.000	.003	.000	.000	.000	.000	.000	.000	
	N	151	151	151	151	151	151	151	151	151	151	151	151	151

***. Correlation is significant at the 0.01 level (2-tailed).*

**. Correlation is significant at the 0.05 level (2-tailed).*

APPENDIX H: CORRELATION TABLEs FOR PERCEPTION OF NETWORK RESILIENCE AND PERCEPTION OF NETWORK INTEGRITY

Perception of Network Resilience Scale Correlations

		Red_I	Relat_I	Resou_I	Rapid_I	Robust_I
Red_I	Pearson Correlation	1	.460**	.403**	.425**	.345**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	151	151	151	151	151
Relat_I	Pearson Correlation	.460**	1	.724**	.725**	.781**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	151	151	151	151	151
Resou_I	Pearson Correlation	.403**	.724**	1	.744**	.796**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	151	151	151	151	151
Rapid_I	Pearson Correlation	.425**	.725**	.744**	1	.676**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	151	151	151	151	151
Robust_I	Pearson Correlation	.345**	.781**	.796**	.676**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	151	151	151	151	151

**. Correlation is significant at the 0.01 level (2-tailed).

Perception of Network Integrity Correlations

		Integ_1A	INTEG_2	INTEG_3
Integ_1A	Pearson Correlation	1	.287**	.332**
	Sig. (2-tailed)		.000	.000
	N	151	151	151
INTEG_2	Pearson Correlation	.287**	1	.595**
	Sig. (2-tailed)	.000		.000
	N	151	151	151
INTEG_3	Pearson Correlation	.332**	.595**	1
	Sig. (2-tailed)	.000	.000	
	N	151	151	151

**. Correlation is significant at the 0.01 level (2-tailed).

APPENDIX I: CORRELATION TABLE FOR STATE ATTRIBUTES

State Level Variable Correlations (n=51)

		HDI	MDD	ED	BUDGET	FT Employ	Popul	SoVI
HDI	Pearson	1	-.389**	.224	.176	.178	.140	-.589**
	Sig.		.005	.115	.221	.215	.329	.000
MDD	Pearson	-.389**	1	.298*	.261	.270	.277*	.328*
	Sig.	.005		.034	.067	.058	.049	.019
ED	Pearson	.224	.298*	1	.274	.416**	.409**	-.102
	Sig.	.115	.034		.054	.003	.003	.475
BUDGET	Pearson	.176	.261	.274	1	.586**	.666**	-.129
	Sig.	.221	.067	.054		.000	.000	.373
FTEmploy	Pearson	.178	.270	.416**	.586**	1	.833**	-.190
	Sig.	.215	.058	.003	.000		.000	.186
Popul	Pearson	.140	.277*	.409**	.666**	.833**	1	-.086
	Sig.	.329	.049	.003	.000	.000		.549
SoVI	Pearson	-.589**	.328*	-.102	-.129	-.190	-.086	1
	Sig.	.000	.019	.475	.373	.186	.549	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

APPENDIX J: INFORMED CONSENT LETTER

Dear State Emergency Management Agency Employee,

You are being invited to take part in a research study to learn more about state emergency management networks resilience, a key element to the reduction of disaster related economic and social costs. Please take a few moments to respond to this important research on state emergency management networks and share your perspective.

EXPLANATION OF RESEARCH

- The PURPOSE of this research is to evaluate the influence of both individual and state attributes on your perception of the resilience of your state's emergency management network.
- Participation involves your anonymous response to a 33 question online survey.
- This survey asks your opinion about different aspects of the state emergency management network that the agency you work for participates in. You may complete this survey from any computer with internet access.
- This survey is anticipated to take approximately 10 minutes to complete.
- You must be 18 years of age or older to take part in this research study.

If you consent to participate, please follow the hyperlink embedded in the Project Title below to the survey. Thanks very much!

Project Title: INFLUENCE OF PERSONAL AND STATE LEVEL VARIABLES ON PERCEPTION OF STATE EMERGENCY MANAGEMENT NETWORK RESILIENCE IN 47 STATES

Principal Investigator: ***Victoria Jennison RN, MS***
Faculty Supervisor: *Dr. Thomas Wan*

Study contacts for questions about the study, request results, or to report a problem: *If you have questions, concerns, or complaints* Victoria Jennison RN, MS Doctoral Student, Public Affairs Program, College of Health and Public Affairs, (321) 693-3236 or toryjennison@knights.ucf.edu or Dr. Tom Wan, Faculty Supervisor, Associate Dean for Research, Professor of Public Affairs 407-823-3678 or by email at twan@mail.ucf.edu.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

APPENDIX K: IRB EXEMPTION LETTER

University of Central Florida

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Victoria F. Jennison**

Date: **April 15, 2011**

Dear Researcher:

On 4/15/2011, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Project Title:	The Influence of Emergency Management Network Integrity on Network Resilience and State Well-Being in 50 States.
Investigator:	Victoria F Jennison
IRB Number:	SBE-11-07589
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Kendra Dimond Campbell, MA, JD, UCF IRB Interim Chair, this letter is signed by:

Signature applied by Joanne Muratori on 04/15/2011 02:27:25 PM EDT

Joanne Muratori

IRB Coordinator

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