Geoenvironmental Disasters

RESEARCH Open Access

A temporal social resilience framework of communities to disasters in Australia

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Abstract

Despite the current interest in and need for studies in the conceptualization and measurement of social resilience to hazards and disasters, there remains significant research gaps within this area. This study seeks to fill one such gap via the provision of an innovative unified framework of social resilience across three disaster phases (i.e., pre-disaster, response and recovery) using a quantitative research method. We utilized the survey results from the New South Wales State Emergency Service volunteers to validate a conceptualization framework that aimed to enhance social resilience across all disaster phases. This study had shown the positive correlation between identified indicators and social resilience but varying in impact strength depending on disaster phase.

Keywords: Disaster resilience, Social resilience, Climate disaster, Quantitative research, Online questionnaire, Disaster phases, Social resilience framework, Temporal framework resilience

Introduction

Over the past few decades, and particularly since the 1970s, the frequency of natural disasters per year has been increasing worldwide (Pollach, 2014). In addition to an increase in the number of potential natural disasters, there has also been an overall increase in the intensity of these events recorded globally by the Center for Research on the Epidemiology of Disaster (CRED) via the International Disaster Database. The frequency and impact of natural disasters is on an upward trajectory and, considering the future influence of climate change and population growth, is projected to continue to increase. Among these increases in natural disasters, the incidences of climate-related disasters have progressively increased over the last few decades (Leaning and Guha-Sapir, 2013). Nellemann et al. (2008) predict that this incidence of climate-related natural disasters will only continue to increase, while the number of geophysical disasters has remained stable.

According to CRED and the United Nations International Strategy for Disaster Reduction report (UNISDR, 2015), increases in these climate-related disasters will result in a greater impact on human lives, well-being and property. Populations are generally growing and, in many areas, settlement patterns (Morley et al., 2012) have exacerbated the potential effect of these disaster events on the population (Joerin et al., 2012). Thus, the frequency of disasters is increasing (Pollach, 2014), populations are increasing and the number of individuals living in vulnerable locations is increasing. The culmination of these factors has resulted in greater risk to communities and their economies, environment and infrastructure, as well as the well-being of individuals within these communities.

Australia is of interest when studying the socio-economic aspects of natural disasters owing to the concentration of people living in flood-prone areas (Morley et al., 2012). Between 1990 and 2014, 74% of Australian disasters were flood- or storm-related (UNISDR, 2015). These disasters, which are climate-related, have a severe negative effect on the communities, economies, environments and infrastructure where they occur. The Australia Business Roundtable for Disaster Resilience and Safer Communities report estimates that when social impacts (i.e., mental health and chronic disease related to disaster impact) are included alongside critical infrastructure, disasters are estimated to have a financial impact of $33 billion per year by 2050 in Australia in real terms (Insurance Australia Group Limited, 2016). Limiting this impact by enhancing resilience is thus a critical economic and social issue.

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Therefore, it is necessary to minimize the risks related to potential disasters and enhance the capacity of these communities to be able to cope with any future impacts. Broadly speaking, the ability of individuals and communities to cope with disturbances or changes and to maintain adaptive behavior is termed resilience. Building resilience to natural hazards requires increasing the capacity to cope with the event and its aftermath, as well as increasing the capacity to learn about hazards and risks, change behavior, transform institutions and adapt to a changing environment (Maguire and Cartwright, 2008). Therefore, it is imperative that the determinants of disaster resilience are identified and measured so that issues may be addressed and capacities improved (Klein et al., 2003, Cutter et al., 2008).

Short-term emergency responses to flood disasters are usually the focus of studies; however, addressing social resilience factors for people who are exposed to flood disasters should be addressed (Weldegebriel and Amphune, 2017). The assessment of disaster resilience using indicators can be a key element in the planning and management of extreme events by providing a tool to identify priorities for improvement and to monitor change. In the past two decades, and since the publication of the Social Vulnerability Index (Cutter et al., 2003), there has been a dramatic increase in the number of studies that have aimed to provide methodology to measure the various aspects of disaster risk, resilience or vulnerability (Beccari, 2016).

There is, however, no standard method; approaches can be top-down or bottom-up, qualitative or quantitative, use primary or secondary data and can be designed for scales ranging from local through to national (National Research Council, 2015). The focus of the assessment may be on resilience (e.g. Cutter et al. 2010), vulnerability (e.g. Cutter et al. 2003) or risk (e.g. United Nations University Institute for Environment and Human Security and Alliance Development Works, 2014) but essentially each method aims to assess some variation of the capacity within a community to withstand and recover from natural hazards. Further, assessment approaches may also be at different stages of development, existing only as a conceptual model (e.g. Norris et al., 2008; Parsons et al., 2016) or as a conceptual model developed into an applied assessment such as Cutter et al.'s (2008) disaster resilience of place (DROP) model. The DRP model clusters around the following six core dimension: ecological, social, economic, institutional, infrastructure and community competence, and conceptualizes resilience as a changeable process that is dependent upon pre-existing conditions and the severity, duration and time between disasters, as well as a range of additional external factors (Cutter et al., 2008). Working from a geographical perspective, Zhou et al. (2010) developed a notable approach to resilience within local community contexts via a model of disaster resilience of 'loss-response' of location based on the following three distinct dimensions: the temporal and spatial scales of resilience, as well as the attributes of hazard-affected bodies. Beccari (2016) conducted a comparative analysis of 106 different published methods including Bijan et al.'s (2014) (Khazai et al., 2014) ontology of 55 methods and the EMBRACE project (Birkman et al., 2012), which incorporated 32 different frameworks across a broad range of indicators. Despite a solid foundation of literature addressing social resilience to disasters and various approaches for its measurement, there are currently no studies that address social resilience using quantitative measures across the emergency management temporal stages or key areas of operation.

These emergency management stages in Australia are termed prevention, preparedness, response and recovery (Council of Australian Governments, 2011). For the present study, the two pre-disaster phases, prevention and preparedness, are grouped into a single preparedness phase and cover the entire time period prior to the disaster. The response phase begins once the community has been influenced by a crisis event. This phase is often marked by a coordinated effort to ensure that the needs of those involved in the disaster are met, such as search and rescue efforts. The nature of the response efforts, however, is determined by the immediate and most pressing needs of those impacted. Finally, the recovery phase occurs after the immediate needs of the community are met and the disaster is no longer presenting further impact to the community (Waugh and Streib, 2006). This phase seeks to restore the impacted individuals and communities to a state in which recovery is no longer occurring.

Khalili et al. (2015) provided a social resilience framework across these three phases of disaster; however, their study is limited because of its focus on qualitative interviews with subject matter experts. Hinds (1989) argued that applying both qualitative and quantitative methods to a research problem "increases the ability to rule out rival explanations of observed change and reduces skepticism of change-related findings". Similarly, Hussein (2015) argued that quantitative research can be used to validate qualitative findings. Therefore, the quantitative approach applied within the present study to the qualitative findings from Khalili et al.'s (2015) study is essential for the development of a unified social resilience framework, which is required to improve current efforts to address social resilience. Thus, by conducting quantitative research using an online survey with New South Wales (NSW) State Emergency Services (SES) volunteers from locations throughout NSW who had experienced significant flooding events, the present study attempted to validate the resilience framework in the study by Khalili et al. (2015).

Social resilience and indicators

Resilience is a broadly used concept that is applied across a range of disciplines including engineering, psychology,

science, sociology and economics. Initially, resilience was derived from the Latin word resilio, meaning 'to jump back' (Klein et al., 2003). As a broad encompassing topic, the present study begins by setting parameters on the dimensions of resilience, which are conceptualized via the four dimensions of organizational, technical, social and economical (Bruneau et al., 2003). Of these dimensions, the present study focuses on the social component of resilience as it relates to disasters. Specifically, social resilience—defined as the ability of communities to withstand the external social shocks of a disaster or disaster-related event (Adger, 2000)—occurs through three phases: pre-disaster, disaster response, and disaster recovery. According to Keck and Sakdapolrak (2013), social resilience to disasters is widely debated, but includes three capacities that are the ability to cope with, adapt to and transform from disaster shocks to social systems. Social resilience is the ability of a community to absorb shocks, recover from disturbances and avoid negative and potentially irreversible effects (Resilience Alliance, 2007). Social resilience is important across these phases to protect the community against loss by enhancing the capacity of communities during the pre-disaster and response phases, and to improve their capacity to rebuild and return to normal after the event (Zhou et al., 2010). Although researchers have provided definitions, albeit often inconsistent, of social resilience to disasters, "the questions of how social resilience can be properly defined, how it can be operationalized, measured and analyzed, and how it might be fostered (or hindered) are far from being settled yet" (Keck and Sakdapolrak, 2013).

The concept and term 'community' has various meanings and applications. It is invariably used to refer to collectives of people joined by shared geography, interests and concerns, or identity (Jewkes and Murcott, 1996). Common definitions of community highlight the existence within a geographical boundary, and engagement in ongoing social interaction and psychological connections to both the surrounding people and place as key components (Christenson and Robinson, 1980). In the present study, community refers to a social unit larger than a household whose members share common values and live in some physical proximity to each other.

Disaster impact is a factor of both the scale of the disaster and the ability of the community to withstand the shock of the disaster. Thus, social resilience reflects the preparedness and response of the community and is dependent on social situations in the communities during both the pre- and post-disaster contexts (Boyce, 2000). Disaster response, therefore, both affects and influences social resilience (Tobin and Whiteford, 2002). To capture this cyclical relationship, it is necessary to consider all three disaster phases and the associated social indicators of resilience to best develop a unified social resilience framework. Such indicators—defined herein as parameters for assessing the social resilience of a community—include community demographics, participation, learning processes related to disaster, and leadership (Miller et al., 2010). These indicators represent variable aspects of communities, i.e., they vary the phases of a single disaster, but also over time across different disasters. By advancing the understanding of the indicators associated with social resilience, the present study provides implications for increasing those capacities identified as positive factors of social resilience or decreasing those identified as negative factors of social resilience. This begins with recognition of these indicators and their impact in disaster social resilience. The purpose of the present study is thus to improve the ability of a community to withstand the shock of disasters by improving social resilience.

Table 1 shows Khalili et al.'s (2015) two-dimensional framework on social resilience indicators for the three disaster phases as temporal factors. In all, there are 14 indicators included in the model:

- *community participation* – the engagement of community members in organizations and activities within their community, including resident associations, neighborhood (Perkins and Long, 2002) watches, self-help groups and religious congregations (Paton et al., 2001; Perkins et al., 2002)
- *education* – disaster-related formal and informal training and educational activities within communities (Paton and Johnston, 2001)
- *exchange of information* – information flow within a community (Rohrmann, 2000)
- *learning* – learning from previous disasters (Zhou et al., 2010)
- *shared information* – distributing information within a community (Ink, 2006)
- *social support* – support from the neighborhood (Kaniasty and Norris, 1999; Norris et al., 2008)
- *sense of community* – feeling of belonging to a community or place (Paton and Johnston, 2001)
- *trust* – trust in the neighborhood (Enemark, 2006)
- *demographic information* – i.e., age, gender, socio-economic status/income, health, history, education, cultural/religious belief, or populations with special needs (Tobin, 1999; Cutter et al., 2010)
- *improvisation-inventiveness* – community creativity and innovation to devise a solution for enhancing resilience (Demchak, 2006; Lalonde, 2011)
- *coping style* – the ability to manage, adapt to and deal with stressful situations (Miller et al., 1999)
- *leadership* – leadership within a community (Harland et al., 2005; Hegney et al., 2008)

Table 1 Khalili et al.'s (2015) Framework on Social Resilience Indicators Matrix

	Social Resilience Indicators		
High	Community Participation Education Exchange information Learning Shared Support Sense of community Trust	Community Participation Exchange information Shared information Social Support Sense of community Trust	Community Participation Exchange information Learning Shared information Social Support Sense of community Trust
Medium	Demographic information	Coordination	Community efficacy
Low	Improvisation inventiveness Coping Style Leadership	Coping Style Leadership	Improvisation inventiveness Coping Style Leadership
	Pre-Disaster	Response	Recovery

- *coordination* – community works together
- *community efficacy* – community belief in their own capabilities of performing and completing jobs (Moore et al., 2004).

The social resilience indicators are presented as low, medium or high influence based on the analysis of previous studies and subject matter expert interviews. This framework presents Khalili et al.'s (2015) interpretation of the NSW SES subject matter expert perspectives on the relationship between social resilience indicators and impact. The present study proposes metrics for and quantitatively tests this model as the two-dimensional framework is limited by its reliance on qualitative data. As qualitative research is used to contextualize understandings of a phenomenon, such as social resilience to disasters, it is not appropriate to derive a framework from such a small sample size. Generalization is uncommon from qualitative data, yet the framework uses the interview data to propose a general framework of social resilience.

Methods

Quantitative research relies on empirical investigation methods (Given, 2008) that utilizes numerical, quantifiable data to conduct research (Grove and Burns, 2005). Thus, quantitative research seeks to explain phenomena via the collection of numerical data that are analyzed using statistical methods (Aliaga and Gunderson, 2005). The phenomena being analyzed in the present study are climate-induced disasters such as floods and storms. The study used quantitative methods to verify Khalili et al.'s (2015) social resilience model by the generation of metrics that were used to quantify the framework and test the hypotheses by statistical methods. Social resilience was quantified as the dependent variable and the framework indicators were the independent variables for the purpose of generalization from the sample to the greater population. Quantitative research not only allows the generalization of results, but is also considered more objective for testing hypotheses (Fink, 2002). The relationship examined via the quantitative methods was that existing between social resilience indicators identified via prior qualitative research and social resilience data collected from NSW SES volunteers from locations throughout NSW who have experienced significant flooding events. This relationship was examined to generalize the study findings across different disaster environments. The research relied on robust scientific procedures to ensure reliability and validity during the process of quantifying the previously qualitative data of social resilience indicators.

In adhering to quantitative methodologies, the present study proceeded as follows:

- formulation of hypotheses
- definition of variables
- identification of the sample
- development of instruments
- data collection
- data analysis.

Hypotheses were formulated based on the pre-identified phenomena of disasters and were designed to assess the previous identified impact of social resilience indicators as the independent variables on social resilience as the dependent variable. The hypotheses were based on the association between the dependent variable of social resilience and the 14 indicators discussed previously. Thus, the present study quantitatively assessed the relationship between social resilience and social resilience indicators, assuming that every disaster phase has its own individual indicators that influence social resilience.

To test these hypotheses, it was necessary to collect data on the community perspective of social resilience. NSW SES volunteers are ideal for providing this information because they formed part of the larger population that the present study aimed to generalize, they are members of the local community and generally have an advanced understanding of disaster management through their work

with the SES. Although the SES is generally considered an emergency response agency, SES volunteers are active in providing education, advice, support and other services throughout all the disaster phases.

An online survey of volunteers from NSW locations who had experienced significant flooding events was conducted with questions designed to solicit quantitative data for the dependent and independent variables. Questions were designed to measure social resilience for each of the three disaster phases using a 5-point Likert scale from Strongly Disagree (+ 1) to Strongly Agree (+ 5), which provided a measurement of the attitudes of the respondents on each of the social resilience indicators (Bowling, 2014). In addition to the scaled questions, the instrument also included open- and close-ended questions that addressed demographic and similar information for developing survey weights. Sample questions from the survey instrument are provided in Table 2.

The survey instrument was pilot tested to ensure that it produced reliable and valid measurements and that the questions generated the data required to test the research hypotheses. Validity was tested to ensure control of any systematic error in data measurement (Norland, 1990) and to check that the instrument measured what it was designed to measure (Bryman and Cramer, 1994; Kerlinger, 2011). Content validity was ensured via the reliance on expert opinions in the development of the scaled items (Rattray and Jones, 2007). Specifically, the instrument pre-testing and piloting stage allowed us to identify questions that were not clear to the respondents and that could potentially introduce bias into the data. This resulted in question order changes, the re-wording of some questions and the addition or elimination of some questions.

Table 2 Sample Questions from Online Questionnaire

Community Participation:
Pre-disaster: People in my area have participated in local activities, events (e.g., festivals, fetes, fairs) or public meeting.
During disaster: People in my area tried to help each other and make a positive difference to the community.
Post-disaster: People in my area have been involved in volunteer activities intended to benefit the community (e.g., fundraising, clean-up days, etc.) or have contributed money, food or clothing to local causes, charities, or others.
Please rate your agreement with the following statements on a scale of 1 to 5, where:
1. Strongly Disagree
2. Disagree
3. Neither Agree nor Disagree
4. Agree
5. Strongly Agree
6. Don't Know

Data collection

The NSW SES volunteers were pre-identified as the target population and the survey was administered through Survey Monkey, an online survey administration website. Online surveys were selected for this research for their expediency, cost and accuracy in collecting and managing data as well as their ability to collect data anonymously. For the final survey, SES volunteers received a direct link to the online survey in an email on October 21, 2015 from the SES commissioner. The survey link remained open for three months until closing on January 21, 2016. During this time, the survey received a total of 126 responses.

Data analysis

After the survey was closed, the data was processed, cleaned and analyzed in the context of the research hypotheses. After removing incomplete responses (not finished), non-responses (blank), and "don't know" responses, 42 were found to be incomplete and 84 were found to be fully complete. To analyze the data, each column of the data matrix was assigned a label based on the social resilience indicator that the data measured. The 5-point Likert scale ordinal data were treated as interval-level data and were subjected to interval-level data analysis procedures. The variable frequencies, means and weights were calculated to provide descriptive statistics for each of the columns. Cronbach's alpha was calculated to test the internal reliability and was found to be greater than 90%. Pearson's bivariate correlation coefficients were then calculated to assess the relationship between variables. This included calculating correlations for each of the three disaster phases to assess the relationship between each of the tested social resilience indicators and the social resilience expectancy. The scale shown in Table 3 was developed to determine the strength of the relationship based on the Pearson's correlation coefficient R-value.

Table 4 provides the correlation coefficients for the pre-disaster indicators categorized by strength of outcome from very strong to moderate. The pre-disaster shared information indicator showed the highest correlation to pre-disaster social resilience (rho = 0.821, $p \leq 0.000$ at 2-tailed, $n = 77$).

Table 5 provides the correlation coefficients for the during disaster indicators categorized by strength of outcome from strong to weak. The during disaster shared

Table 3 Correlation Relationship Strength

R-Value	Strength of Relationship
.00–.19	Very weak
.20–.39	Weak
.40–.59	Moderate
.60–.79	Strong
.80–1.0	Very strong

Table 4 Pre-Disaster Phase Correlations

Strength	Pre-Disaster Indicators	Correlation
Very Strong	Pre-Disaster–Shared Information	.821**
	Pre-Disaster–Community Participation	.815**
Strong	Pre-Disaster–Leadership	.693**
	Pre-Disaster–Sense of Community	.679**
	Pre-Disaster–Demographic Information	.636**
	Pre-Disaster–Education	.603**
Moderate	Pre-Disaster–Improvisation/Inventiveness	.553**
	Pre-Disaster–Exchange Information	.548**
	Pre-Disaster–Coping Style	.541**
	Pre-Disaster–Trust	.509**
	Pre-Disaster–Social Support	.492*
	Pre-Disaster–Learning	.471**

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

information indicator showed the highest correlation to during disaster social resilience (rho = 0.668, $p \leq 0.000$ at 2-tailed, $n = 69$).

Table 6 provides the correlation coefficients for the post-disaster indicators categorized by strength of outcome from very strong to moderate. The post-disaster coping style indicator showed the highest correlation to post-disaster social resilience (rho = 0.844, $p \leq 0.000$ at 2-tailed, $n = 65$).

Table 7 demonstrates in general (across the three disaster phases) that social resilience indicators have a moderate to strong positive correlation with social resilience. Shared information had the highest correlation to social resilience when aggregated across the three phases with coping style and community participation indicator each also showing strong positive correlations.

Results and discussion

Following the generation and analysis of the data, the indicators were organized into a two-dimensional matrix

Table 5 During Disaster Phase Correlations

Strength	During Disaster Indicators	Correlation
Strong	During Disaster–Shared Information	.668**
	During Disaster–Community Participation	.641**
Moderate	During Disaster–Coping Style	.537**
	During Disaster–Coordination	.489**
	During Disaster–Trust	.438**
Weak	During Disaster–Exchange Information	.365**
	During Disaster–Social Support	.363**
	During Disaster–Leadership	.349**
	During Disaster–Sense of Community	.331**

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

Table 6 Post-Disaster Phase Correlations

Strength	Post-Disaster Indicators	Correlation
Very Strong	After Disaster–Coping Style	.844**
Strong	After Disaster–Shared Information	.650**
	After Disaster–Learning	.627**
Moderate	After Disaster–Improvisation/Inventiveness	.581**
	After Disaster–Social Support	.567**
	After Disaster–Trust	.555**
	After Disaster–Sense of Community	.553**
	After Disaster–Exchange Information	.535**
	After Disaster–Leadership	.506**
	After Disaster–Community Efficacy	.437**
	After Disaster–Community Participation	.424**

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

organizing social resilience indicators by disaster phase and level of impact to verify Khalili et al.'s (2015) framework (see Table 8). The indicators in both Table 1 and Table 8 are ordered by strength of association with outcomes. As presented in the revised matrix in Table 8, several social resilience indicators, such as community efficacy and education, were only relevant in a single disaster phase, while other indicators, such as learning, were relevant in two of the three phases, but most indicators were present across all three disaster phases. Additionally, while many indicators were significant in more than one phase, they generally held different levels of significance in each phase. 'Sense of Community,' for instance, was of high importance during the pre-disaster phase, of low importance during the response phase and of medium importance during the recovery phase.

Table 7 Aggregate (Across All Phases) Correlations

Strength	Social Resilience Indicators	Correlation
Strong	All Phases–Shared Information	.742**
	All Phases–Coping Style	.726**
	All Phases–Community Participation	.668**
Moderate	All Phases–Leadership	.592**
	All Phases–Coordination	.582**
	All Phases–Exchange Information	.578**
	All Phases–Improvisation/Inventiveness	.556**
	All Phases–Learning	.555**
	All Phases–Sense of Community	.554**
	All Phases–Social Support	.539**
	All Phases–Education	.482*
	All Phases–Demographic Information	.466**
	All Phases–Community Efficacy	.456**
	All Phases–Trust	.452**

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

Table 8 Social Resilience Indicators Matrix

	Social Resilience Indicators		
High	Shared Information Community Participation Leadership Sense of Community Demographic Information Education	Shared Information Community Participation	Coping Style Shared Information Learning
Medium	Improvisation/Inventiveness Exchange Information Coping Style Trust Social Support Learning	Coping Style Coordination Trust	Improvisation/Inventiveness Social Support Trust Sense of Community Exchange Information Leadership Community efficacy Community Participation
Low		Exchange Information Social Support Leadership Sense of Community	
	Pre-Disaster	Response	Recovery

Overall, the findings showed that the 14 indicators were all individually associated with social resilience as they all had a positive statistically significant correlation with social resilience and each indicator had a different level of impact on social resilience. The data analysis revealed the following seven findings that are important to the study and for advancing the current state of knowledge on social resilience in disasters:

- First, all 14 social resilience indicators had a positive correlation with social resilience as viewed by the SES volunteers sampled in the study.
- Second, aggregated across all three disaster stages, all social resilience indicators had a relationship that was categorized as a high or medium impact with shared information, community participation and coping style exhibiting the greatest impact on social resilience.
- Third, in agreeance with Rohrmann (2000) and Ink (2006), the social resilience indicator of shared information had a significant impact on social resilience. Shared information was determined to be the factor having the greatest impact in the aggregated data.
- Fourth, coping style was determined to be the indicator with the second greatest overall impact, which aligns with Miller et al.'s (1999) finding that coping style had a strong influence on social resilience.
- Fifth, the data aligns with Paton and Johnston's (2001) conclusion that community participation is a strong indicator of social resilience. The results demonstrated that community participation had a high impact on social resilience during the pre- and post-disaster phases, as well as a medium impact in the during disaster phase.
- Sixth, the research also aligned with that of Harland et al. (2005) in that leadership is an important factor for social resilience. The present study showed that leadership had a moderate impact on social resilience overall, with a high impact during the pre-disaster phase, a low impact in the during disaster phase and medium impact in the post-disaster phase.
- Finally, all pre- and post-disaster social resilience indicators had a high or medium impact, indicating that community stakeholders should concentrate on indicators in these phases to improve community social resilience.

The survey results and analysis also showed that every phase of disaster had its own individual indicators that influenced social resilience. The relationships among indicators were all found to be statistically significant; therefore, these can be generalized to a broader framework and used to develop policies for improving and maintaining resilience. The extant literature generally approaches social resilience to disasters as an entire entity; however, refining the indicators for each of the disaster phases individually will allow approaches to be more targeted to the factors that are of greatest impact and provide meaning to social resilience throughout all disaster phases.

While this study confirmed that all 14 social resilience indicators shared a temporally assigned positive statistically significant relationship with the different disaster phase outcomes, the placement of the social indicators within the matrix did not perfectly align with that proposed by Khalili et al. (2015). As previously stated, qualitative research designs do not yield the data that are considered appropriate for generalization in this manner, which in part explains the differences, but also provides justification for

presenting the quantitative based model as one that has greater reliability. Beyond qualitative-quantitative differences, Khalili et al.'s (2015) data were collected from community leaders and subject matter experts, while the data in the present study were collected from volunteers in the communities. Some of the variation in the results can be attributed to the differing perceptions of these two samples. For example, analysis of the interview data collected from the SES experts indicated that leadership within the community was a low impact social resilience indicator. Their view indicated that only leadership in emergency preparedness and response organizations was important; however, their positional bias led them to view community leadership as being insignificant. However, from a community perspective, leadership within a community plays a significant role in social resilience especially before and after disasters.

Conclusion

The present study used survey data to refine previously postulated frameworks of social resilience, focusing on social resilience indicators provided by Khalili et al. (2015). Based on the conclusion that all 14 social resilience indicators presented by Khalili et al. (2015) were positively correlated with social resilience, but varying in impact strength depending on disaster phase, the present study found that social resilience was composed of varied indicators with different levels of effectiveness during different phases of a disaster. The indicators represented the ability of a community to cope with a disaster to minimize social damage and to return to their previous quality of life level or greater. In the present study, the indicators of each phase and their impact level on social resilience were based on the views of SES volunteers and other communities might have different views. The results indicated that social resilience can be conceptualized and measured at multiple levels and across different phases of a disaster. These social resilience indicators can be used to build community resilience to minimize risk and impact associated with disasters. The present study aimed to quantify Khalili et al.'s (2015) model to better assess and measure social resilience related to disasters. In providing metrics for each of the social resilience indicators, this study enabled greater precision of the role of these indicators to be shown. The temporal dimension of the indicators allows disaster managers and responders greater precision in allocating much needed resources to improve social resilience and limit the impact of disasters on communities (Khalili et al., 2015). Thus, the quantified influence of this disaster phase approach provides emergency stakeholders with the ability to assess the presence of these indicators in their communities and use their assessments to develop strategies for mitigating risk and improving response.

Abbreviations

CRED: Centre for Research on the Epidemiology of Disaster; DROP: Disaster resilience of place; NSW: New South Wales; SES: State Emergency Service; UNISDR: United Nations International Strategy for Disaster Reduction

Acknowledgements

We thank the SES and council members who provided us with the opportunity to gather relevant information for our research.

Funding

This work did not have any funding.

Availability of data and materials

Not applicable.

Authors' contributions

SK researched and developed the manuscript. MH and PM read and reviewed the final manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

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Received: 24 January 2018 Accepted: 25 November 2018
Published online: 18 December 2018

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