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Differential Mental Health Impact Six Months After Extensive River Flooding in Rural Australia: A Cross-Sectional Analysis Through an Equity Lens

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Background: Northern New South Wales in Australia is a "hotspot" for natural disaster declarations with recent extensive flooding in early 2017. With limited knowledge about how climate change affects mental health and resilience, robust local assessments are required to better understand long-term impact, particularly in communities prone to extreme weather events.

Methods: Six months post-flood, a cross-sectional survey of adults living in the region during the flood was conducted to quantify associations between flood impact and psychological morbidity (post-traumatic stress (PTSD), anxiety, depression, suicidal ideation) for different exposure scenarios, and respondent groups. We adopted a community-academic partnership approach and purposive recruitment to increase participation from marginalized groups.

Results: Of 2,180 respondents, almost all (91%) were affected by some degree of flood-related exposure at an individual and community level (ranging from suburb damage to home or business inundated). Socio-economically marginalized respondents were more likely to have their homes inundated and to be displaced. Mental health risk was significantly elevated for respondents: whose home/business/farm was inundated [e.g., home inundation: PTSD adjusted odds ratio (AOR) 13.72 (99% CI 4.53–41.56)]; who reported multiple exposures [e.g., three exposures: PTSD AOR 6.43 (99% CI 2.11–19.60)]; and who were still displaced after 6 months [e.g., PTSD AOR 24.43 (99% CI 7.05–84.69)].

Conclusion: The 2017 flood had profound impact, particularly for respondents still displaced and for socio-economically marginalized groups. Our community-academic partnership approach builds community cohesion, informs targeted mental health disaster preparedness and response policies for different sectors of the community and longer-term interventions aimed at improving community adaptability to climate change.

Keywords: natural disasters, mental health, inequality, indigenous populations, low income populations

INTRODUCTION

There is compelling evidence and wide consensus that anthropogenic activities are causing climate change, leading to more frequent extreme weather events with adverse consequences for public health, disproportionately so for the poorest populations (1, 2). In academic and public discourse on health impacts from climate change, connection to mental health has generally been neglected (3). Robust and context-specific case-studies assessing extreme weather and mental health are therefore required to strengthen the case for effective adaptation, particularly in community settings, and incorporating the experience of diverse socio-economic groups (4, 5).

Risk of climate change effects and adverse impacts are known to exacerbate existing inequalities in all countries regardless of their level of development (1, 6). Landmark international agreements, such as the United Nations' Agenda 2030 (Sustainable Development Goals) and the Sendai Framework for Disaster Risk Reduction (2015–2030), recognize the need for complementary action on climate change mitigation and adaptation, with inequality a key global challenge to creating sustainable and resilient communities (7, 8). The Sendai Framework advocates a community-centered preventive approach to disaster risk. It recommends that government agencies be multi-sectoral and inclusive in designing and implementing policies by engaging all relevant stakeholders, including women, children, seniors, people with pre-existing health conditions, people with low socio-economic status and Indigenous communities. In this way, understanding and managing disaster risk encompasses all dimensions of exposure, vulnerability, and capacity of individuals and communities in formulating regional and local risk reduction policies (8).

Floods are the most expensive weather-related event in Australia with an average annual damage bill of over $300 million (9). Such annual assessments do not regularly incorporate costs from less visible social impacts (e.g., mental health and well-being or employment), nor how impacts are differentially distributed amongst societal groups. While river (fluvial) flooding is the most common flood disaster globally, the majority of research incorporating mental health impact has focused on floods that arise from typhoons/cyclones and coastal surges (extreme tides combined with severe storms) (10). Fluvial flooding has unique characteristics in that it occurs after extended periods of heavy rain within river catchments that can lead to high velocity, large volume coastal, and inland flows with little warning. Within the context of increasing frequency of extreme rainfall events (due to a warming climate and intensified hydrological cycles) and urbanization of flood zones, the probability of flood events occurring and their intensity will further increase the severity of human impacts (11). One such event occurred in late March/early April 2017, with heavy rainfall from ex-Tropical Cyclone Debbie (the second most destructive cyclone in Australia) (12) causing devastating flooding in Queensland, Northern New South Wales (NSW) and subsequently the North Island of New Zealand. Record breaking rainfall occurred in Northern NSW (12). In Lismore (one of the larger population centers in the region with over 25,000 residents) (13), the levee was overtopped for the first time and the ensuing flood was the worst since 1974, inundating the central business district and low-lying residential areas close to town (14). Murwillumbah (population ∼9,000) in the Tweed River Valley experienced its highest flood level in recorded history (14).

In Australia, inequality in the distribution of income and wealth has resulted in sectors of the community experiencing significant poverty, disproportionately so within the Aboriginal and Torres Strait Islander population (15, 16). Compared to NSW overall, the Northern NSW region has: higher proportions of people living with underlying vulnerability; lower median household incomes; and greater government income support reliance (e.g., single parent, disability, unemployment, and youth payments) (13). The region also has a higher proportion of Aboriginal people (4.1%) compared to the state average (2.9%) (13). The region experiences fluvial flooding regularly (over 30 flood disaster declarations in the decade 2004–2014) (17), yet there is little information about underlying risk, that is, individual, and community-level factors that mediate flood impact on mental health which, in turn influences the adaptive capacity of the community to climate change effects.

As espoused by the Sendai Framework, this project aims to understand the interplay of factors that may contribute to local disaster risk and adaptive capacity to inform risk reduction policies. We utilized a systems thinking-based social-ecological approach in a community-academic partnership to develop a "*flood impact on mental health framework*" (the framework) (18). It describes putative relationships between flood exposure and mental health and well-being and maps the influence of mediating factors from personal (e.g., socio-demographic factors, "personal social capital," and individual social support), community (e.g., community cohesion) and organizational levels of analysis (such as pre-flood mitigation systems, disaster relief responses, and community and health service responses) (18). Our objectives were to explore the relationships described within the framework with a focus on key interest groups within our region, such as farmers, business owners, young adults (16–25 years), older people aged over 75 years and socio-economically marginalized subpopulations (18). The project forms the baseline for a planned longitudinal cohort study to improve understanding of mental health and well-being impact from river flooding in the short (1–2 years) and medium-term (3–5 years). It will enable identification of opportunities to mitigate risk and inform strategies to strengthen public health services and psychosocial resilience to future flooding.

This paper presents initial results from the project and contributes new knowledge by quantifying the associations between intensity of fluvial flood exposure (how many sites of importance were flooded) and five mental health problems. These include two directly event-linked problems [still distressed about the flood and flood-related post-traumatic stress disorder (PTSD)] and illustrates how these associations vary according to socio-economic circumstance. There is also opportunity to contribute learnings to an international initiative tracking health impacts from climate change (19).

FIGURE 1 | Study location.

METHODS

Study Design

A cross-sectional survey was undertaken 6 months after flooding in communities within six Northern NSW Local Government Areas (Ballina Shire, Tweed Shire, Richmond Valley, Kyogle, Byron Shire and Lismore City) (**Figure 1**) which have an estimated population of 247,000 (∼202,000 aged 15 years and over) (13). Community members 16 years and older resident in Northern NSW at the time of the flood were invited to participate.

The project's community-academic partnership approach was integral to the design, recruitment to and implementation of the study (18). It included the recruitment of local community members to promote the survey and the establishment of two project specific Community Advisory Groups (CAGs) in the regional centers, Lismore and Murwillumbah. The CAGs comprised local health and community organizations, business groups, and state and local government authorities who have responsibility for flood planning, emergency response, mental health service provision, and/or advocacy and support for the project's key interest groups. Guided by the framework and together with experts in survey design and in floods and mental health research, the CAGs reviewed the face and content validity of the questionnaire and proposed topics that should be included (e.g., level and perceived adequacy of support received from government and community agencies at the time of the flood). The survey was piloted with 30 individuals from various socio-demographic backgrounds (recruited via the CAGs and the research team) and subsequently revised.

The survey was available online and in paper form between September and November 2017. The online version of the survey, suitable for use on computers and mobile telephones, was generated using Qualtrics software (version Sept–Nov 2017, Qualtrics Provo Utah). Potential respondents were provided with participant information and advised that completion of the questionnaire would signify consent to participate in the study.

We utilized a purposive snowball sampling technique to recruit respondents via personal, social and local organizational networks, the CAGs and other business groups and community organizations. This was supplemented by an extensive local media campaign (print, broadcast, and social media), advertising campaign and a door-to-door survey conducted at the end of the recruitment period in randomly selected neighborhood blocks from flooded areas of Lismore and Murwillumbah (to assess response bias, participation rates, and effectiveness of recruitment strategies) (18). The advertising campaign included posters and paper surveys (with reply-paid postage) left in central community locations such as post offices, libraries, coffee shops and store fronts of charitable organizations such as Lifeline, St Vincent de Paul and the Salvation Army. Project staff promoted the survey at various community events including farmers' markets, and through the local postal service, we deposited postcards in residential mailboxes with information on accessing the survey. As an incentive, we also offered respondents an opportunity to enter a lottery style draw upon survey completion for a $100 local shopping voucher (18).

Our aim was to recruit participants from the local community experiencing different degrees of flood impact, including the key groups described earlier, some of which are hard to reach via conventional sampling strategies. Where certain subgroups are few in number and a degree of trust is required to support their participation, community-partnered snowball sampling approaches or "ascending" methods (working from the ground up) are preferable to "descending" methods, such as household surveys (20, 21). As our interest was to quantify relationships between flood impact and psychological morbidity, extrapolation to other populations was a secondary consideration (22). Our sampling methodology therefore targeted our key interest groups as well as a broad cross-section of the community, encouraging residents to participate regardless of whether they felt the 2017 flood had affected them.

Measures

The questionnaire included participants' socio-demographic characteristics, flood exposure measures (including evacuation and displacement) and mental health screening tools. Socio-demographic data were age, sex, Aboriginal, and Torres Strait Islander status, relationship status, employment status, type of income support payments, and educational qualifications.

Flood exposure measures were selected *a priori* and included self-reported damage to five physical infrastructure sites: suburb; non-liveable areas of their home (e.g., garden shed, garage); liveable areas of their home (e.g., bedrooms); income-producing

property (business/farm); and the home of a significant other as well as evacuation and length of displacement. Those who did not indicate any of these exposures were termed "non-exposed" and this group formed the internal comparison against which exposed groups were compared. To examine cumulative impacts, we derived a cumulative exposure index for individuals by summing the number of damage sites experienced. The index ranged from zero (no sites damaged) to five (experienced all five).

We measured health status using brief clinical screening tools for depression, anxiety, and post-traumatic stress. The Patient Health Questionnaire (PHQ-2) for depression has previously shown acceptable diagnostic accuracy, reliability, construct and criterion validity, and sensitivity to change in primary care and other clinic settings in western countries (23, 24). The Generalized Anxiety Disorder scale (GAD-2) has shown acceptable diagnostic accuracy from meta-analysis of validation studies in western countries (pooled sensitivity 0.76 and specificity 0.81) (25, 26). The Post Traumatic Stress Disorder Checklist (PCL-6) has shown adequate diagnostic performance in United States primary care settings (sensitivity 0.80 and specificity 0.76) including for underserved and minority populations (27, 28). Cut-points for probable diagnosis were $\geq$3 for the PHQ-2/GAD-2 and $\geq$14 for the PCL-6 (23, 25, 27). For the PCL-6, the checklist was introduced as a list of complaints that people sometimes have after severe rain and flooding to relate responses to the flood. We also used a single suicidal ideation item from the Screening Tool for Assessing Risk of Suicide ("Over the past 4 weeks, have you personally had any thoughts about ending your life?") (29) and a single measure of continuing impact 6 months after the flood ("Are you still currently distressed about what happened during the flood?") from the Brief Weather Disaster Trauma Exposure and Impact Screen (30).

Participants

A total of 2,530 people responded to the survey (76% online), 350 (14%) of whom were excluded from the primary analyses because of missing socio-demographic data, leaving a final sample of 2,180. Minimal differences in parameter estimates and no differences in patterns of results were found between the full dataset and the dataset with missing socio-demographic records removed (**Supplementary Table 1**). Respondents were predominantly women (69%) and people aged between 35 and 74 years (82%). ∼4% of respondents were Aboriginal and/or Torres Strait Islander and over a quarter of respondents were receiving income support at the time of the flood (**Table 1**). Recruitment strategies were successful in raising awareness of the survey with around 50% of residents within the door-knock areas (18). Of those door-knocked, ∼5% had already completed the survey, the majority of which were women (69%). The sampling strategy was not intended to obtain representation of the broader Northern NSW population, but rather to obtain respondents in each category of interest to enable comparison of experience among the key interest groups.

Statistical Methods

Separate binary logistic regression models were constructed to calculate the odds of experiencing symptoms (yes/no) related to five types of mental health problem (continuing distress, suicidal ideation or probable depression, anxiety, or PTSD) by single exposure (damage to suburb, non-liveable areas, liveable areas, and home of a significant other and evacuation and length of displacement) as well as cumulative flood exposure relative to the non-exposed group. We adjusted the models for all measured socio-demographic characteristics. Potential interactions between these characteristics were checked for significance. Respondents who did not complete a health outcome measure were excluded from analysis for that indicator only. Adjusted predictions of the probability of reporting a mental health outcome for different levels of exposure were calculated by using the marginal standardization method. As we conducted multiple analyses, the p-value was set conservatively at <0.01. Stata (version 15, StataCorp) was used for statistical analysis.

RESULTS

About nine-in-ten respondents reported being affected in some way while ∼9% were classified as non-exposed (no damage to surrounding infrastructure, no evacuation or displacement). Around three-quarters reported suburb damage and almost two-thirds had a home of a significant other flooded (**Table 1**). Liveable areas were flooded in the homes of over one-in-five respondents while almost as many had their income-producing properties (businesses/farms) flooded. Compared to their proportions in the total respondent group, there were higher proportions of Aboriginal and Torres Strait Islander people (6 vs. 4%), single people (41 vs. 32%), those not in paid employment (40 vs. 31%) and income support recipients (42 vs. 29%) who reported flooding in liveable areas of their home. Approximately 14% ($n = 315$) of respondents reported being displaced and 4% ($n = 85$) were still living elsewhere 6 months after the flood (**Table 2**).

Over one-fifth (22%) of respondents reported being still distressed about the flood, 16% with probable anxiety, 15% probable PTSD, 15% probable depression and 7% suicidal ideation. Around 27% of respondents reported at least one of these and about 20% reported two or more of these problems. The odds of any mental health problem were significantly elevated across most exposure measures compared with the non-exposed group, particularly those whose homes and/or businesses/farms were evacuated or flooded and those who were still displaced after 6 months (**Table 2**). Respondents who had their homes or businesses inundated had between two to three times greater odds of reporting suicidal ideation than the non-exposed group.

Increasing intensity of exposure, as indicated by the cumulative exposure index, was associated with the likelihood of progressively worse mental health (**Table 2**). For example, for every incremental increase in the index, there was an exponential doubling of the odds across exposure levels of continuing distress and PTSD compared to non-exposed respondents. The predicted

TABLE 1 | Socio-demographic profile of survey respondents by exposure category.

				Flood exposure damage *n* (%)				
		***n* (%)**	**Non-exposed**	**Home of a significant other**	**Suburb**	**Non-liveable areas of home**	**Liveable areas of home**	**Business/farm**
Total respondents		2,180 (100)	198 (9)	1,380 (63)	1,659 (76)	1,035 (47)	460 (21)	365 (17)
Age group	16–34	309 (14)	19 (10)	215 (16)	234 (14)	141 (14)	68 (15)	35 (10)
	35–54	902 (41)	79 (40)	593 (43)	687 (41)	435 (42)	192 (42)	173 (47)
	55–74	894 (41)	85 (43)	542 (39)	685 (41)	433 (42)	188 (41)	150 (41)
	75+ years	75 (3)	15 (8)	30 (2)	53 (3)	26 (3)	12 (3)	7 (2)
Gender	Women	1,500 (69)	128 (65)	963 (70)	1144 (69)	713 (69)	309 (67)	225 (62)
	Men	680 (31)	70 (35)	417 (30)	515 (31)	322 (31)	151 (33)	140 (38)
Indigenous status	Indigenous	77 (4)	3 (2)	67 (5)	58 (3)	50 (5)	28 (6)	9 (2)
	Non-indigenous	2,103 (96)	195 (98)	1313 (95)	1601 (97)	985 (95)	432 (94)	356 (98)
Relationship status	Single	704 (32)	49 (25)	469 (34)	556 (34)	374 (36)	188 (41)	73 (20)
	In a relationship/ married	1,476 (68)	149 (75)	911 (66)	1103 (66)	661 (64)	272 (59)	292 (80)
Education level	University degree	957 (44)	100 (51)	576 (42)	701 (42)	405 (39)	162 (35)	146 (40)
	Other	1,223 (56)	98 (49)	804 (58)	958 (58)	630 (61)	298 (65)	219 (60)
Employment status	Paid employment (part- or full-time)	1,511 (69)	125 (63)	967 (70)	1140 (69)	681 (66)	278 (60)	298 (82)
	Other	669 (31)	73 (37)	413 (30)	519 (31)	354 (34)	182 (40)	67 (18)
Income support*	Yes	643 (29)	53 (27)	434 (31)	523 (32)	376 (36)	195 (42)	60 (16)
	No	1,537 (71)	145 (73)	946 (69)	1,136 (68)	659 (64)	265 (58)	305 (84)

**Income support at time of the flood: age pension; veteran payment; single parent support; unemployment support; youth allowance; education support; disability support pension; carer payment.*

probability of reporting continuing distress for someone scoring one on the index was 8% and it was 67% for someone scoring five (5 and 52%, respectively for PTSD) (**Table 3**).

Of those displaced, 58% had their homes flooded. Other evacuees whose homes were not flooded lived elsewhere for other reasons including damaged roads and landslips. Out of the 230 people who returned home within 6 months, 56% ($n = 129$) did so within 4 days. Compared to short-term evacuees, those displaced for longer than 6 months were twice as likely to report being still distressed and having symptoms of PTSD, anxiety and depression (**Table 3**).

The results of the logistic regression analyses for Aboriginal and Torres Strait Islander respondents and respondents in receipt of income support are presented in **Table 4**. Compared to others (and based on unadjusted odds ratios), these respondents were more likely to be evacuated, have their homes inundated and/or be displaced for 6 months or more. While there was a higher proportion of Aboriginal and Torres Strait Islander respondents receiving income support payments (44%) compared to non-Indigenous respondents (30%), there was no significant interaction between these socio-demographic categories with respect to reporting flood exposures or mental health outcomes. After adjusting for severity of flood exposure (cumulative exposure index), Aboriginal and Torres Strait Islander respondents were significantly more likely to report probable anxiety and depression and income support recipients were more likely to report probable PTSD, anxiety, depression, and suicidal ideation compared to other respondents (**Table 4**).

DISCUSSION

Our results demonstrate elevated psychological morbidity among survey respondents 6 months after the 2017 severe flooding in Northern NSW with greater impact on marginalized respondent groups. Rates of still being distressed about the flood, probable PTSD, anxiety, and depression, and suicidal ideation were particularly elevated in response to three types of exposure: those whose homes or businesses were flooded; those who faced multiple exposures; and those who endured lengthy displacement. Respondents already experiencing socio-economic marginalization were more likely to be exposed and, if exposed, to have elevated risk of psychological morbidity (i.e., after accounting for extent of flood damage).

Our findings are in keeping with those of previous studies describing how flooding across different scenarios of impact can harm mental health (30–32). For instance, after severe cyclones buffeted Queensland in the summer of 2010–11, flood damage to areas outside individuals' homes (e.g., in their suburbs, the homes of close relatives/friends, and income-producing properties) was linked to elevated rates of mental health problems, and residents in the most disadvantaged areas were more likely to report home damage. Further, if exposed to these forms of damage, they were likely to report much higher rates of psychiatric morbidity than equally-exposed people in more advantaged areas (30). We add to this knowledge in five ways: by discriminating between damage inside and immediately outside the home (yards/gardens); by

TABLE 2 | Adjusted odds ratios (AOR) of mental health outcomes across exposure measures compared with "non-exposed" respondents ($N = 2,180$).

			Still distressed ($n = 486$; 22%)			Probable PTSD ($n = 332$; 15%)			Probable anxiety ($n = 343$; 16%)			Probable depression ($n = 335$; 15%)			Suicidal ideation ($n = 159$; 7%)		
Exposure[#]		***N***	***n* (%)**	**AOR^**	**99% CI**	***n* (%)**	**AOR^**	**99% CI**	***n* (%)**	**AOR^**	**99% CI**	***n* (%)**	**AOR^**	**99% CI**	***n* (%)**	**AOR^**	**99% CI**
Non-exposed		198	12 (6)	1.00		6 (3)	1.00		11 (6)	1.00		13 (7)	1.00		10 (5)	1.00	
Home of significant other affected		1380	380 (27)	5.53	(2.51–12.20)**	259 (19)	7.36	(2.24–24.19)**	260 (19)	3.21	(1.40–7.38)**	247 (18)	2.80	(1.24–6.30)*	111 (8)	1.37	(0.56–3.36)
Suburb affected		1659	440 (27)	5.09	(2.32–11.18)**	306 (18)	6.09	(2.04–18.13)**	303 (18)	3.14	(1.37–7.19)**	291 (18)	2.48	(1.13–5.43)*	141 (9)	1.46	(0.60–3.56)
Non-liveable areas affected		1035	347 (34)	7.00	(3.17–15.50)**	247 (24)	8.32	(2.78–24.86)**	228 (22)	3.92	(1.70–9.05)**	220 (21)	3.06	(1.39–6.75)**	109 (11)	1.75	(0.71–4.32)
Liveable areas affected		460	217 (47)	12.14	(5.36–27.47)**	161 (35)	13.72	(4.53–41.56)**	137 (30)	5.42	(2.29–12.79)**	134 (29)	4.37	(1.93–9.89)**	68 (15)	2.59	(1.02–6.62)*
Evacuated home		333	151 (45)	9.87	(4.25–22.92)**	118 (35)	14.53	(4.29–49.24)**	106 (32)	5.40	(2.23–13.06)**	97 (29)	4.21	(1.76–10.08)**	52 (16)	2.58	(0.97–6.88)
Displaced < 6 months		230	75 (33)	6.34	(2.65–15.13)**	64 (28)	9.73	(3.08–30.78)**	53 (23)	4.17	(1.66–10.48)**	49 (21)	2.98	(1.22–7.26)*	34 (15)	2.46	(0.90–6.75)
Displaced ≥ 6 months		85	57 (67)	25.70	(9.20–71.81)**	46 (54)	24.43	(7.05–84.69)**	45 (53)	14.50	(5.15–40.85)**	38 (45)	8.38	(3.04–23.10)**	18 (21)	3.17	(0.96–10.39)
Business/farm affected		365	134 (37)	8.36	(3.62–19.28)**	89 (24)	11.60	(3.63–37.07)**	88 (24)	5.47	(2.24–13.40)**	81 (22)	4.28	(1.81–10.13)**	43 (12)	2.88	(1.06–7.85)*
Evacuated business		305	114 (37)	8.79	(3.68–20.99)**	72 (24)	13.59	(3.90–47.40)**	73 (24)	5.57	(2.17–14.30)**	71 (23)	5.00	(2.00–12.55)**	36 (12)	2.94	(1.03–8.40)*
Cumulative exposure index[†]	1	428	34 (8)	1.30	(0.53–3.21)	18 (4)	1.29	(0.37–4.48)	29 (7)	1.10	(0.43–2.86)	34 (8)	1.11	(0.45–2.72)	19 (4)	0.79	(0.28–2.26)
	2	551	84 (15)	2.82	(1.22–6.47)*	54 (10)	3.20	(1.02–10.01)*	74 (13)	2.39	(1.00–5.73)	67 (12)	1.79	(0.77–4.13)	18 (3)	0.56	(0.19–1.61)
	3	514	136 (26)	5.30	(2.34–11.98)**	99 (19)	6.43	(2.11–19.60)**	86 (17)	2.77	(1.17–6.61)*	91 (18)	2.48	(1.09–5.65)*	49 (10)	1.74	(0.68–4.46)
	4	383	177 (46)	12.68	(5.57–28.85)**	121 (32)	11.61	(3.80–35.49)**	109 (28)	5.24	(2.20–12.46)**	103 (27)	3.93	(1.72–8.98)**	45 (12)	1.93	(0.74–5.03)
	5	59	40 (68)	31.85	(10.99–92.27)**	31 (53)	32.80	(9.07–118.63)**	29 (49)	14.63	(5.02–42.64)**	24 (41)	8.41	(2.91–24.34)**	18 (31)	7.87	(2.48–25.05)**

CI, confidence interval; N, number within the total sample experiencing the exposure; n, number within the exposure category with the mental health outcome measure.

[#]Exposure categories are not mutually exclusive, hence comparison across exposures must be treated with caution particularly if there are marginal differences between estimates.

^Adjusted for age, sex, Aboriginal and Torres Strait Islander status, relationship status, education qualification, employment status, and income support.

**$p < 0.01$; **$p < 0.001$.*

[†]Cumulative exposure index is the sum of exposures experienced: home of a significant other + suburb + non-liveable area of home + liveable area of home + business/farm. It ranges from zero (non-exposed) to five (all five exposures).

*For unadjusted analyses, please see **Supplementary Table 1**.*

TABLE 3 | Predicted probability (% & 99%CIs) of reporting mental health problems by number of exposures and length of displacement (less than or more than 6 months).

			Still distressed		PTSD		Anxiety		Depression		Suicidal ideation	
		N (%)	%	99% CIs	%	99% CIs	%	99% CIs	%	99% CIs	%	99% CIs
Cumulative exposure index	1	428 (20)	8	(5–12)	5	(2–7)	7	(4–11)	9	(5–13)	5	(2–7)
	2	551 (25)	16	(12–20)	11	(7–17)	15	(11–18)	13	(10–17)	3	(1–5)
	3	514 (24)	26	(21–31)	19	(14–23)	16	(12–21)	17	(13–21)	10	(6–13)
	4	383 (18)	46	(39–52)	29	(23–35)	26	(21–32)	24	(19–29)	10	(7–14)
	5	59 (3)	67	(52–83)	52	(35–68)	49	(32–65)	39	(23–54)	30	(15–45)
Displacement (months)	<6	230 (11)	32	(24–40)	27	(20–34)	23	(16–30)	20	(14–27)	14	(8–20)
	≥6	85 (4)	64	(50–78)	47	(33–62)	49	(34–64)	39	(26–53)	17	(7–27)

TABLE 4 | Odds ratios of flood exposure and mental health outcomes for Aboriginal and Torres Strait Islander respondents and respondents in receipt of income support ($N = 2{,}180$).

Respondents who reported being		Aboriginal & Torres Strait Islander ($n = 77$)		In receipt of income support ($n = 643$)	
		(Reference = non-Indigenous)		(Reference = no income support)	
		Odds ratio[#]	99% CI	Odds ratio[#]	99% CI
Sites of flood damage	Home of significant other	4.35	(1.73–10.93)**	1.35	(1.04–1.75)*
	Suburb damaged	0.95	(0.48–1.90)	1.53	(1.13–2.06)**
	Non-liveable area	2.05	(1.10–3.84)*	1.91	(1.49–2.45)**
	Liveable area	2.28	(1.21–4.29)*	2.16	(1.63–2.87)**
	Home evacuation	2.87	(1.50–5.50)**	2.29	(1.68–3.14)**
	Had to live elsewhere	2.00	(0.99–4.03)	2.13	(1.55–2.94)**
	Displaced ≥6months	3.04	(1.11–8.33)*	3.81	(2.13–6.84)**
	Business/farm damaged	1.02	(0.49–2.10)	1.04	(0.77–1.39)
		Adjusted odds ratio^	99% CI	Adjusted odds ratio^	99% CI
Mental health outcomes	Still distressed	1.93	(0.96–3.86)	1.34	(0.92–1.97)
	Probable PTSD	1.88	(0.91–3.88)	1.75	(1.15–2.68)*
	Probable anxiety	2.16	(1.08–4.33)*	1.89	(1.26–2.85)**
	Probable depression	2.09	(1.04–4.23)*	1.84	(1.22–2.79)**
	Suicidal ideation	0.67	(0.22–2.04)	1.85	(1.06–3.25)*

[#]*Unadjusted odds ratio.*

^*Adjusted odds ratio for other socio-demographic variables and severity of flood exposure.*

*$p < 0.01$; **$p < 0.001$.

quantifying the associations between intensity of exposure (how many of five different places were flooded) and psychological impact; by investigating impacts across five mental health problems, including two that were directly event-linked (still distressed about the flood and flood-related PTSD); by quantifying the nature and amplified degree of impacts on specific marginalized sub-population groups; and by examining fluvial flooding impacts in a rural area of New South Wales.

There was an exponential increase in the likelihood of respondents experiencing continuing distress and flood-related PTSD with each additional exposure. For example, while there was no substantial difference in mental health outcomes between respondents experiencing one exposure compared to non-exposed, those reporting three exposure sites (e.g., home and business and suburb) had, respectively, five and six times the odds of reporting continuing distress and PTSD. Further, while immediate-term evacuation and displacement are known stressors (6, 32), our findings suggest that lengthy displacement is associated with particularly high levels of mental health risk: respondents "still not home" after 6 months had double the probability of reporting continuing distress and symptoms of PTSD, anxiety, and depression when compared to those who were briefly displaced. With almost one-half of respondents reporting three or more exposures and a small but important minority displaced long-term (most of whom also experienced multiple exposures), there is a sub-group of people with a high-risk profile for significant psychological burden following the flood. These people have extensive immediate and medium-term social and health needs and are at elevated risk of long-term psychological morbidity (32). Further investigation into issues prolonging displacement, such as lack of financial assistance

and onerous insurance processes (33) as well as research into the causes and effects of multiple domains of exposure and impact, are required to fully understand how these factors interact to shape mental health, and to minimize risk and build resilience.

In our study, Aboriginal and Torres Strait Islander respondents and respondents in receipt of income support fall disproportionately within the high-risk sub-group described above. It is recognized that elevated risk of psychological morbidity is pre-existing for these groups due to their poorer underlying health and socio-economic status (6). This double disadvantage is a significant issue in characterizing the potential impacts of climate change (8). For example, compared to non-Indigenous respondents, Aboriginal and Torres Strait Islander respondents had four times the odds of reporting damage to the home of a significant other. Extended close family and community connections may form a protective factor for Aboriginal and Torres Strait Islander communities when faced with adversity (34) but this very closeness may also be a risk factor. That is, the more closely connected a community is, the more it may be likely to "feel" harm to its members. This may help explain why Aboriginal and Torres Strait Islander people are at high risk of disruption to mental health-protective close social connections and support when their communities experience a flood disaster. Understanding the contexts operating within subpopulations will help inform intervention strategies that build on existing strengths to promote resilience and pre-emptively address key vulnerabilities.

Implications for Public Health

Our findings have improved understanding of the local context by highlighting the relationship between severity of flood exposure and mental health outcomes, including for respondents most in need. Joint design and analysis of the study with community representatives has enabled the sharing of knowledge and recognition of strengths and gaps in local policy and practice, particularly for at-risk groups. For example, NSW emergency services engage with non-government welfare agencies to provide immediate post-disaster support. Our findings underscore the importance of these initiatives and indicate the additional necessity for first responders to be able to assess and react appropriately to multiple or high-risk exposures. Care pathways that are individually tailored and sensitive to specific exposures and risk factors may be more effective in preventing the onset of symptoms and in promoting recovery. In addition, the focus of disaster recovery programs needs to be extended beyond the immediate aftermath given research has shown that mental health problems persist for many years (35). Anecdotal evidence from local service providers in Northern NSW indicated low uptake of mental health services established immediately after the flood. Our next stage of research will focus on the changing nature of mental health needs of respondents over time following a disaster.

More generally, a multi-sectoral agency approach in disaster preparedness and response, consistent with the guidelines from the Sendai Framework, should be used to promote flexible services adapted to meet the needs of community members according to their economic and social circumstance (8). For health systems, this includes empowering people through inclusive processes in designing strategies to mitigate their risks before, during and after disasters, especially among those who may be disproportionately affected by disasters (8). Systems-level focus and action is required to move beyond individual behavioral change interventions (where success relies on individual capacity, opportunity, and resources) toward group-level change strategies that can involve everyone regardless of circumstance and build communities' social capital and underlying resilience (5). Community development approaches, in which local government and community services collaborate to promote social cohesion and well-being, have proven effective in moderating the mental health impacts of persistent drought in rural NSW (36). With guidance from the project's Community Advisory Groups, similar approaches could work for flood-prone communities in the Northern NSW region.

Strengths and Limitations

Our capacity to generalize our findings to other settings has limitations. This is a self-report, cross-sectional design which constrains our ability to make causal inferences: pre-existing mental health status can bias responses and we cannot be sure flood experiences directly caused outcomes (5). Further, our sampling approach was not intended to and should not be used to estimate population prevalence for either exposure or for outcome measures. We recommend the magnitude of the adjusted odds ratios and associated confidence intervals reported in our study be interpreted in relation to the sampling approach of our survey and that the risk estimates of psychological outcomes between specific subgroups be interpreted with caution. Nevertheless, our findings are consistent with and meaningfully extend the findings of previous studies which employed potentially more robust (and costly) conventional survey techniques, such as random-digit dialing (landline telephones) and household mailouts (30, 31). Indeed, these studies often report low response rates, selection bias, difficulty identifying appropriate sampling frames and delays in capturing post-event data. They also recognize their inability to adequately capture the experiences of displaced populations. Our pragmatic, purposive sampling approach was able to overcome some of these limitations, enabling us to measure disaster experiences within diverse and hard-to-reach sub-population groups.

We included two mental health measures specifically related to the flood (including PTSD) as well as general measures of depression, anxiety, and suicidal ideation, and we adjusted our analyses by a wide variety of socio-economic factors known to predict psychological morbidity (37). A particular strength of our study [consistent with recommendations from the Sendai Framework (8)] was the inclusion of multiple dimensions of exposure and vulnerability to describe disaster risk. We achieved this by

engaging closely with the community from the outset, utilizing local community, and organizational networks to document experiences of socio-economically marginalized respondents. This co-production and evaluation of knowledge means that our findings are able to directly address community identified priorities. This means, in turn, that our findings are relevant to local organizations' and governments' role in strengthening public health policy and service development processes related to climate change and associated extreme weather events.

CONCLUSION

Six months after the 2017 Northern NSW flood event, survey respondents revealed a substantial continuing mental health burden; we have characterized and quantified this burden and its inequitable distribution in a rural Australian context. The community-academic partnership approach used in this study means that local communities helped generate the knowledge they need to begin work to address the findings. In the context of climate change, weather disasters will become increasingly frequent, intense, and unpredictable with the potential for correspondingly severe effects on mental health. A recent systems framework highlights the complexity of interactions between climate change and mental health (5). Such frameworks encourage research partnerships to trial tailored adaptation interventions aimed at building community cohesion and disrupting the pathways of harm that link climate change and mental health. Our study is an early example of such an approach. We have an opportunity to establish long-term collaborative research to develop and evaluate such interventions. These further studies will help describe the scale, intensity, and duration of climate change related mental health impacts in a rural setting, assist with stakeholder driven assessment and strengthening of mental health support systems and, therefore, help formulate effective adaptation for an Australian community most vulnerable to extreme weather events.

DATA AVAILABILITY STATEMENT

The datasets generated for this study are available on request to the corresponding author.

ETHICS STATEMENT

The study was approved by the University of Sydney Human Research Ethics Committee (reference-2017/589) and the Aboriginal Health and Medical Research Council Human Research Ethics Committee (reference-1294/17). Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

VM performed the data analysis. VM, JL, and HB interpreted the data and drafted the manuscript. All authors contributed to the study design, critically reviewed draft versions and provided important intellectual content during revisions, and accept accountability for the overall work.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2019.00367/full#supplementary-material

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Article

Belonging and Inclusivity Make a Resilient Future for All: A Cross-Sectional Analysis of Post-Flood Social Capital in a Diverse Australian Rural Community

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Abstract: In 2017, marginalised groups were disproportionately impacted by extensive flooding in a rural community in Northern New South Wales, Australia, with greater risk of home inundation, displacement and poor mental health. While social capital has been linked with good health and wellbeing, there has been limited investigation into its potential benefits in post-disaster contexts, particularly for marginalised groups. Six months post-flood, a cross-sectional survey was conducted to quantify associations between flood impact, individual social capital and psychological distress (including probable post-traumatic stress disorder). We adopted a community-academic partnership approach and purposive recruitment to increase participation from socio-economically marginalised groups (Aboriginal people and people in financial hardship). These groups reported lower levels of social capital (informal social connectedness, feelings of belonging, trust and optimism) compared to general community participants. Despite this, informal social connectedness and belonging were important factors for all participant groups, associated with reduced risk of psychological distress. In this flood-prone, rural community, there is a pressing need to build social capital collectively through co-designed strategies that simultaneously address the social, cultural and economic needs of marginalised groups. Multiple benefits will ensue for the whole community: reduced inequities; strengthened resilience; improved preparedness and lessened risk of long-term distress from disaster events.

Keywords: floods; mental health; social capital; inequality; Indigenous populations; low-income populations

1. Introduction

In disaster contexts, the value of close social networks is well documented for logistical, financial and emotional support, alleviating psychological stress following traumatic experiences [1]. Disaster management policies are increasingly drawing attention to investment in social resources as another form of 'capital' to help communities and individuals more effectively prepare, survive and recover from disaster events such as floods [2,3]. Social capital acts as 'informal insurance', facilitating a community's collective action to accelerate recovery [4]. However, previous post-disaster research has

shown that social capital does not always benefit everyone due to existing prejudices that may slow down recovery for marginalised groups [4].

Social capital has been variously described and measured either as individual perspectives or as community-level structures and characteristics [5]. Widely adopted in public health research, Putnam's concept of social capital takes a macro-level approach, placing it as a collective resource strengthened by civic engagement, informal social connectedness, trust and social identity to facilitate group-level coordinated action with individual-level health consequences [5–7]. Putnam's conceptualisation contains an implied causal mechanism whereby forms of community participation (e.g., volunteering) influence levels of social cohesion (e.g., social trust) [8,9].

Bonding, bridging and linking social capital describe network characteristics and flows of resources within and across groups: bonding refers to resources accessed within tightly knit groups of similar socio-economic and demographic profiles; bridging refers to resource flow between groups with weaker ties and different profiles, and; linking refers to resource flow across gradients of authority and power [7,10]. Where bonding social capital provides resources and support for 'getting by', bridging and linking social capital are important for 'getting ahead' [11]. All forms of social capital may work to promote health but they can also have costs and negative consequences for marginalised individuals [12,13], particularly where bonding capital reinforces exclusive social identities to the detriment of others external to the group [7,10]. Similarly, a lack of bridging capital reinforces social hierarchies [13]. Marginalised groups experience gaps in all forms of social capital [12,14,15] which may lead to increased health inequalities [10,16]. Therefore, having a better understanding of how social capital operates within a community may offer insights into how positive aspects (such as bridging ties) can be intentionally strengthened to more effectively address inequalities and improve the health and wellbeing of marginalised groups [5,13].

Social capital in health and resilience research is generally measured by its structural and cognitive components [6,8]. The structural component describes the nature and extent of community participation through which individuals develop social networks and the cognitive component describes the social cohesion resulting from community participation [8,9] or what people 'do' and 'feel' [17]. Personal social cohesion is assessed through individual subjective perceptions of levels of belonging, social trust (trust in strangers), generalised reciprocity (kindness of strangers) and optimism (hope for the future) [6]. Mental health may both be a product of or facilitator for social capital [9]. Longitudinal studies have demonstrated a positive, bi-directional relationship between mental health and structural components of social capital: better mental health leads to greater community participation/social connectedness and greater participation/connectedness leads to better mental health [9,18], including following a flooding event [19]. In this reciprocal relationship, social connectedness is a stronger, more consistent predictor of mental health than mental health is of social connectedness [18].

In 2017, record-breaking rainfall in Northern New South Wales (NSW) from ex-Tropical Cyclone Debbie (the second most destructive cyclone in Australia) caused widespread flooding, inundating local business districts and residential areas on a scale not seen in over forty years [20]. Shortly after, a community-academic partnership was formed to design and implement a study examining potential relationships between flood exposure and mental health and wellbeing outcomes [21]. Two Community Advisory Groups (CAGs) were established in Lismore and Murwillumbah, the main population centres of the region. They consisted of local health and community organisations, business groups and state and local authorities who have responsibility for flood planning, emergency response, mental health service provision and/or advocacy and support for particular subgroups within the community such as farmers, business owners, Aboriginal and Torres Strait Islander people and the socio-economically marginalised. Together with the CAGs, a conceptual framework was developed (the flood impact framework) which theorises pathways between flood exposure and psychological outcomes influenced by mediating factors at personal, community and organisational levels (e.g., socio-demographics, community cohesion, organisational disaster relief efforts) [21]. Based on published evidence, social capital was included as one of many potential mediators. It was predicted that greater levels of

community participation and social cohesion would be protective against psychological distress and that this relationship would vary for different groups including marginalised people in the region. We define 'marginalised' as people with " ... compromised or severely limited access to the resources and opportunities needed to fully participate in society and to live a decent life. Marginalised people experience a complex, mutually reinforcing mix of economic, social, health and early-life disadvantage, as well as stigma" (page 4 in [15]). A better understanding of how social processes work for these groups in a post-disaster context could improve the participatory co-design of resilience-building strategies, a process that in itself may promote social capital [22,23].

Northern NSW is a flood-prone region with over 30 flood disaster declarations in the decade from 2004 to 2014 [24]. Compared to state-level population characteristics, the Northern NSW rural region has higher proportions of people living with an underlying vulnerability, lower median household incomes and greater government income support reliance (e.g., single parent, disability, unemployment, and youth payments) [25]. The region also has a higher proportion of Australia's First Nations people (4.1%) compared to the state average (2.9%) [26]. It is important to note that Aboriginal and Torres Strait Islander status does not in itself indicate marginalisation [15]; rather, it is the common intergenerational disadvantage and ongoing systemic racism that leads to a significant proportion experiencing marginalisation.

During the 2017 flood, marginalised groups (Aboriginal and Torres Strait Islander participants and participants in receipt of income support) were disproportionately impacted by the flood with a greater risk of home inundation, displacement and adverse mental health outcomes [27]. Despite substantial evidence that social capital can promote health and wellbeing, there has been limited empirical investigation into its potential mitigating effect against adverse psychological outcomes following weather-related disasters and how this may vary for marginalised groups. This study investigates at an individual level, associations between the components of social capital (community participation and personal social cohesion) and psychological distress following a major flood event in rural Australia. It examines how social capital has different effects on mental health for marginalised groups relative to other participants. Our aim is to use these findings to highlight what might or might not work in intervention design to assist community groups to strengthen social capital and adaptive capacity within this flood-prone region.

2. Materials and Methods

Data were taken from a cross-sectional survey of adults (16 years and older) in Northern NSW, six months after the region experienced extensive flooding. The questionnaire was formulated on the basis of the flood impact framework described above and outlined in our study protocol [21]. To minimise survey fatigue, the questionnaire contained instructions advising participants of the choice to complete a short version of the questionnaire (that included items on participants' socio-demographic characteristics, flood exposure and their psychological health) or a longer version (all of the above as well as measures of community participation and personal social cohesion). A small prize draw (gift voucher for a local business) was offered as an incentive, with an increased number of entries given for completion of the full questionnaire. The prize draw was not advertised as part of the survey recruitment process.

To comprehensively understand the psychological impact within the community, we aimed to recruit participants from different socio-economic backgrounds experiencing different degrees of flood exposure. We utilised a local community-partnered purposive snowball sampling technique, where the CAGs reached out to their networked constituents offering support and encouraging completion of the questionnaire. This approach was particularly important for certain sectors of the community, as a degree of trust is required to engage socio-economically marginalised groups, including Aboriginal and Torres Strait Islander people and people living with disadvantage. For the purpose of this analysis, we defined the latter as recipients of the following types of income support as markers for chronic financial hardship and living with social marginalisation [15]: single parent support; unemployment

support; youth allowance; disability support; and carer support. Our snowball sampling approach was supplemented by an extensive local media (print, broadcast and social media) and advertising campaign, including posters and paper surveys (with reply-paid postage) left in central community locations such as post offices, libraries, coffee shops and store-fronts of charitable organisations such as Lifeline, St Vincent de Paul and the Salvation Army. Project staff promoted the survey at various community events including farmers' markets, and postcards were deposited in residential mailboxes with information on accessing the survey [21].

Our sampling approach resulted in a total of 2046 respondents completing the full version of the survey [21]. Given that most Aboriginal and Torres Strait Islander people in the Northern NSW area identify as Aboriginal, we respectfully use this term while recognising the diversity of First Nations culture that exists within the region. All participants gave their informed consent for inclusion before completing the questionnaire. The study was approved by the University of Sydney Human Research Ethics Committee (reference−2017/589) and the Aboriginal Health and Medical Research Council Human Research Ethics Committee (reference−1294/17).

2.1. Measures

Participants' sociodemographic data included age, sex, Aboriginal and Torres Strait Islander status, relationship status, employment status, type of income support payments and educational qualifications. For flood exposure, a cumulative exposure index (CEI: range 0–5) was derived by summing the number of damage sites experienced out of five possibilities: suburb; non-liveable areas of their home (e.g., garden shed, garage); liveable areas of their home (e.g., bedrooms); income-producing property (business/farm); and the home of a significant other [21].

Self-report measures for post-flood distress included a single ongoing distress item from the Brief Weather Disaster Trauma Exposure and Impact Screen ('Are you still currently distressed about what happened during the flood?') [28] and the Post Traumatic Stress Disorder Checklist (PCL−6) [29], a brief clinical screening tool (cut-point for probable diagnosis ≥14) that was introduced as a list of 'complaints' that 'people sometimes have' after severe rain and flooding. Details of how the Brief Weather Disaster Trauma Exposure and Impact Screen was developed are presented in Appendix A; the measure was field-tested and deployed as part of the Queensland Government's annual Self-Reported Health Status survey following severe flooding in the summer of 2010−11 [28]. It consists of four items adapted from previous research investigating post-traumatic stress disorder (PTSD) and depression following trauma in adults, adolescents and children within the Australian population. The yes/no 'still currently distressed' item from this measure was used for this analysis to allow for assessment of ongoing stress and anxiety related specifically to the flooding event (as distinct from anxiety arising from other causes) and for comparability to other similar studies in which it has been used [28]. For the PCL−6, respondents were asked to rate items on a 5-point Likert-type scale that evaluated experiences of intrusive memories, numbing/avoidance and hyper-arousal symptoms. The PCL−6 has shown adequate diagnostic performance in primary care settings including for minority populations (sensitivity 80–92%; specificity of 72–76%) [30,31]. Outcome variables were coded as binary for ongoing distress (yes/no) and probable PTSD (yes ≥ 14; no < 14).

The questionnaire included measures representing structural and cognitive constructs of social capital: community participation and personal social cohesion, respectively (Table 1). Previous research has proposed an association between these constructs with enhanced community participation building personal social cohesion which, in turn, positively influences mental health and wellbeing [6,8,9], including among Aboriginal respondents [32]. The extent of respondents' agreement with statements that related to community participation and personal social cohesion was reported on a seven-point Likert-scale (the higher the score, the higher the level of agreement). We reversed the scoring for negatively worded statements. We utilised items from the Australian Community Participation Questionnaire that describe different domains of community participation: informal social connectedness (spontaneous, informal in-person connections); civic engagement (participation in

organised activities) and political participation [33]. The use of social media was added as another form of community participation. The breadth of participation was measured by summing the number of participation activities (eleven in total, possible range 0–11). Individuals' subjective perceptions of the quality and quantity of their community participation [6] were also measured. Personal social cohesion comprised an individual's subjective perception of their sense of belonging (self-categorisation as belonging to a group and cognitive evaluation of the perceived social supports available for connecting, confiding and seeking help) [12,34], feelings of belonging (affective or emotional response to group membership) [6], social trust [12,35–37], generalised reciprocity [12,35]) and trait optimism [38]. Dispositional optimism (a tendency to expect good outcomes over bad) has been strongly linked to social trust and a sense of belonging and has been shown to be related to mental health within the Australian population [6,32]. For this reason, it is included as part of the concept of 'personal social cohesion', or the sense of social cohesion present in individuals.

Following data cleaning and coding, we examined the distribution of individual social capital items to determine appropriate analysis techniques. Where Likert-scale scores for the social capital measures were bimodal in distribution, we converted these to binary variables (scores 1–4 allocated 0: unsure or disagree; scores 4–7 allocated 1: agree). Since there was a mixture of ordinal and binary variables, polychoric correlations were used for subsequent confirmatory factor analysis (CFA) as outlined below.

Table 1. Social capital measures used within the Northern NSW Community Recovery after Flood survey.

Construct	Items	Source
	Community Participation	
Informal Social Connectedness	I make time to keep in touch with my friends; I chat with my neighbours when I see them; I spend time with extended family members (relatives who don't live with me)	Australian Community Participation Questionnaire (ACPQ) [33]
Social Media Engagement	I am active on social media (e.g., Facebook, Snapchat, Instagram)	New
Civic Engagement	I take part in community-based clubs or associations (e.g., Rotary, CWA, book club, Lions); I go to arts or cultural events; I attend community events such as farmers' markets, festivals and shows; I take part in sports activities or groups; I volunteer locally (e.g., Meals on Wheels, school fete, Rural Fire Service); I attend worship services or go to prayer meetings	ACPQ [33]
Political Participation	I get involved with political activities (e.g., through interest groups, public meetings, rallies)	Adapted from ACPQ [33]
Perceptions of Participation	I enjoy the time I spend with others socially; I would like to spend more time with others socially	Adapted from Berry, 2008 [39]
Construct	**Personal Social Cohesion**	**Source**
Sense of Belonging	When I feel lonely, there are several people I could call and talk to; I have family or friends I can confide in; I feel that I'm on the fringe in my circle of friends; I don't often get invited to do things with others; There are people outside my household who can offer help in a crisis.	Adapted from Interpersonal Support Evaluation List (ISEL) [34]
Feelings of Belonging	I feel like an outsider; I feel that I belong; I feel included.	Adapted from Berry (unpublished)
Social Trust	Most people keep their word; Most people do what they say they'll do; Most people around here succeed by stepping on others; Most people tell the truth when they're sorting out a problem; You can't be too careful with some people; Most people can be trusted.	Adapted by Berry & Rodgers [36] from Organisational Trust Inventory (OTI) [37] & World Values Survey (WVS) [35]
Generalised Reciprocity	Most people try to be helpful; Most people look out for themselves	Adapted from WVS [35]
Trait Optimism	Overall, I expect more good things to happen to me than bad; In uncertain times, I always expect the best; If something can go wrong for me, it will; I'm always optimistic about my future	Selected from Life Orientation Test – Revised [38]

2.2. Data Analysis

CFA was used to examine how well the previously defined measures of community participation and personal social cohesion fitted with our survey data [40]. For each of the social capital constructs described above, one-factor congeneric models were estimated on polychoric correlation matrices using maximum likelihood estimation with Stata software (StataCorp. 2017. *Stata Statistical Software: Release 15*. StataCorp LLC, College Station, TX, USA) and the user-written command -polychoric- (author Stas Kolenikov, 2016). To derive factor score weights for subsequent regression analysis, CFA was replicated in Amos (Arbuckle, J.L. (2006) Amos Version 25.0, Chicago: SPSS, USA) using asymptotically distribution-free estimation on raw data (polychoric correlation functionality unavailable), an appropriate technique for ordinal, non-normal data, small models and large sample sizes (>1000) [41]. Item loadings and fit statistics were comparable across the two estimation methods (Appendix B). Model goodness of fit was assessed using the comparative fit index (CFI—value of >0.95 indicates excellent model fit) and root mean square error of approximation (RMSEA—<0.05 indicates an excellent model fit, 0.05–0.08 indicates acceptable fit) [40]. Once optimal models were identified, we assessed internal consistency by calculating composite reliability scores using Jöreskog's rho (acceptable score > 0.70).

Following identification of the one-factor congeneric models, two sets of composite measures were developed: unweighted (by taking the mean score of items within the composite); and weighted (taking mean score of items within the composite after applying factor score weights from the CFA). Descriptive statistics were produced for sociodemographic information and the unweighted social capital measures. Differences in sociodemographic variables and social capital scores across respondent groups (Aboriginal; financial hardship; and 'other' (or general respondent group)) were tested using independent sample t-tests/two proportions z-tests and Mann-Whitney U tests respectively. Kendall's rank correlation coefficients (tau-b, T_b) were calculated to examine the strength and direction of bivariate associations within respondent groups. Multiple hierarchical logistic regression models were tested to examine the independent contribution in prespecified order of items theorised to influence mental health outcomes following a flood (socio-demographic characteristics, flood exposure, community participation and social cohesion). While causality cannot be inferred from cross-sectional designs, hierarchical regression analysis allowed examination of the *plausibility* of the concept that community participation is associated with greater personal social cohesion which, together, supports positive mental health outcomes. Both weighted and unweighted social capital composite variables were tested in the models, however, there was no substantive difference between the analyses with respect to independent variables that significantly influenced mental health outcomes. Hence, unweighted results are reported as they are easier to interpret and replicate if needed in future analyses.

Prior to multivariate analysis, we tested for interactions between sociodemographic characteristics and (i) flood exposure and (ii) social capital variables to examine how the combination of personal factors with flood experience, social participation and social cohesion were associated with reporting each psychological issue. Given the number of interactions tested, we utilised a conservative *p*-value (<0.01), to guide the addition of statistically significant interactions to the relevant multivariate model step as described below.

Four blocks of variables (sociodemographic factors, flood exposure, community participation and personal social cohesion) were added sequentially to assess the unique proportion of variance each contributed to mental health problems. Tjur's 'coefficient of discrimination' (*D*—the difference in mean of predicted probabilities of having symptoms of psychological distress versus no symptoms), analogous to the coefficient of determination (R^2) in linear models, was used to evaluate the explanatory power of each block [42]. Non-significant contributors to explaining variance in psychological outcomes were removed from each step starting with the variable with the lowest standardised beta coefficient. Changes in beta values from one step to the next were examined to assess mediation effects in the relationship between community participation, social cohesion and mental health. The model was re-evaluated after each deletion until only significant predictors (*p*-value < 0.05) remained in each

model. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported for a total of six separate hierarchical logistic regression models calculated for two flood-related outcome measures ('ongoing distress' and 'probable PTSD') for each key interest group (Aboriginal respondents; respondents in receipt of financial hardship support; and 'other' respondents). Respondents who did not complete a health outcome measure were excluded from analysis for that indicator only.

3. Results

The CFAs were carried out on the full respondent dataset (n = 2046); results are detailed in Appendix B and summarised in Table 2. 'Attending worship services' (standardised loading = 0.22) was not strongly associated with the Civic Engagement construct. We included this item separately in subsequent regression analyses rather than attempt to fit it in a CFA. The WVS items measuring Generalised Reciprocity ('most people try to be helpful', 'most people look out for themselves') were weakly correlated in our dataset (polychoric ρ = 0.23). These, too, were added separately in regression analyses. The remaining items demonstrated acceptable scale reliability (ρ) and goodness of fit (CFI and RMSEA values) within their CFAs and were retained in one-factor model solutions (Table 2).

Table 2. Confirmatory Factor Analysis for composite social capital constructs using polychoric correlation matrices (n = 2046).

Construct	Factor Loadings (Range)	CFI	RMSEA	95%CI	ρ Reliability
Informal Social Connectedness	0.60–0.83	1.000	0.000	(0.000–0.040)	0.72
Civic Engagement	0.45–0.81	0.991	0.058	(0.041–0.078)	0.73
Sense of Belonging	0.43–0.86	0.997	0.048	(0.028–0.071)	0.75
Feelings of belonging	0.67–0.88	1.000	0.000	(0.000–0.050)	0.85
Social Trust	0.36–0.82	0.997	0.032	(0.016–0.049)	0.77
Trait Optimism	0.55–0.88	1.000	0.029	(0.000–0.073)	0.82

CFI: Comparative Fit Index; RMSEA: root mean square error of approximation; 95% CI: Confidence Interval.

Of the total 2046 respondents who completed the full version of the survey, 1888 who provided complete sociodemographic data constituted the dataset for analysis. Of the respondent group, 3.5% (n = 67) were Aboriginal and 15% (n = 287) were respondents in financial hardship. Over one-third of Aboriginal respondents (n = 24) were also in receipt of types of income support related to chronic hardship. To obtain mutually exclusive groups and to minimise confounding, these were retained in the Aboriginal respondent group and excluded from the financial hardship category. Overall, the majority of respondents were women (69%, n = 1304) and aged between 45 to 64 years (53%, n = 995) (Table 3). Aboriginal and financially disadvantaged respondents were more likely to be younger, single, unemployed and have lower educational attainment. In the six months immediately following the flood, approximately one in five respondents was still distressed and one out of seven reported probable PTSD. There were higher proportions of Aboriginal and financial hardship respondents indicating ongoing distress and probable PTSD compared to 'other' respondents.

Table 3. Demographic profile and mental health outcomes by respondent group.

Characteristic	Category	Aboriginal Respondents (n = 67; 3.5%)		Respondents in Financial Hardship (n = 287; 15.2%)		Other Respondents (n = 1534; 81.3%)		Total (n = 1888)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age		46.5 ##	14.0	48.8 ###	13.0	52.4	14.4	51.7	14.3
		n	%	*n*	%	*n*	%	*n*	%
Sex	Female	49	73.1	197	68.6	1058	69.0	1304	69.1
Employment	Not in employment ^	15	22.4 ***	132	46.0 ***	144	9.4	291	15.4
Education	University level	20	29.9 ##	88	30.7 ###	735	47.9	843	44.7
Relationship status	Single	31	46.3 ***	178	62.0 ***	401	26.1	610	32.3
Mental health outcomes	Ongoing distress	28	41.8 ***	92	32.1 ***	305	19.9	425	22.5
	Probable PTSD	24	35.8 ***	94	32.8 ***	173	11.3	291	15.4

^ In addition to respondents looking for paid work or unable to work due to long-term illness, 'not in employment' also includes respondents of working age in full-time education, looking after family and home and/or doing regular unpaid volunteer work. Mean/proportion of respondents within the marginalised group is significantly greater (*) or smaller (#) than the mean/proportion in 'other' respondents $^{*,\#}$ $p < 0.05$; $^{**,\#\#}$ $p < 0.01$; $^{***,\#\#\#}$ $p < 0.01$.

There were no significant differences in social capital scores between Aboriginal and hardship respondent groups (Table 4). However, informal social connectedness scores were significantly lower in both marginalised groups compared to 'other' respondents. Civic engagement and breadth of community participation (the number of different types of community activities participated in) was also significantly lower for respondents in financial hardship compared to 'other' respondents. For personal social cohesion, both marginalised groups had significantly lower levels of belonging, social trust and optimism compared to 'other' respondents.

Table 4. Medians and interquartile ranges (IQR) for social capital variables in three respondent groups (higher scores indicate greater agreement with perception statements; n = 1888).

Social Capital Construct	Aboriginal Respondents (n = 67)			Financial Hardship Respondents (n = 287)			Other Respondents (n = 1534)	
	Med.	IQR		Med.	IQR		Med.	IQR
Community participation (score range 1–7)								
Informal Social Connectedness	5.3	(4.0–6.0)	**	5.0	(4.0–6.0)	***	5.7	(4.7–6.0)
Social Media Engagement	5.0	(4.0–6.0)		5.0	(4.0–6.0)		5.0	(3.0–6.0)
Civic Engagement	4.0	(2.8–5.0)		4.0	(3.0–4.8)	***	4.2	(3.2–5.2)
Religious Engagement	2.0	(1.0–4.0)		1.0	(1.0–3.0)	*	2.0	(1.0–4.0)
Political Participation	4.0	(1.0–5.0)		4.0	(2.0–5.0)		3.0	(2.0–5.0)
Breadth of participation (0–11)	6.0	(4.0–7.0)		5.0	(3.0–7.0)	***	6.0	(4.0–8.0)
Perceptions of participation (1–7)								
Enjoyment (enjoy the time spent socially)	6.0	(5.0–6.0)	**	6.0	(5.0–6.0)	***	6.0	(5.0–7.0)
Sufficiency (desire to spend more time socially)	5.0	(4.0–6.0)		5.0	(4.0–6.0)		5.0	(4.0–6.0)
Personal Social Cohesion (1–7)								
Sense of Belonging	4.8	(4.0–6.0)	**	4.8	(4.0–5.6)	***	5.4	(4.6–6.0)
Feelings of Belonging	5.0	(3.3–6.0)	*	4.3	(3.3–5.7)	***	5.3	(4.3–6.0)
Social Trust	4.2	(3.3–4.8)	***	4.0	(3.5–4.7)	***	4.7	(4.0–5.2)
Reciprocity—People try to help	5.0	(4.0–6.0)		5.0	(5.0–6.0)		5.0	(5.0–6.0)
Reciprocity—People look after themselves	5.0	(4.0–6.0)		5.0	(4.0–6.0)		5.0	(4.0–6.0)
Optimism	4.5	(3.5–5.8)	***	4.5	(3.8–5.3)	***	5.3	(4.3–5.8)

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$: Mann-Whitney U tests compare mean rank of scores between Aboriginal and 'other' respondents and financial hardship respondents and 'other' respondents. (Note: Two distributions may have equivalent medians but different rank sums. For example, enjoyment of community participation scores, marginalised respondent groups had lower rank sums (other than those at the median) compared to 'other' respondents.).

In unadjusted analyses, Kendall rank correlation coefficients showed that higher severity of flood exposure was associated with higher levels of ongoing distress and probable PTSD at six months for all respondent groups (Table 5). As expected, most social capital variables were negatively correlated with psychological distress outcomes. Also, as predicted, community participation variables were less likely to be significantly associated with psychological distress compared to personal social cohesion variables (i.e., participation has a more distal influence on psychological outcomes compared to social cohesion). Informal social connectedness was significantly associated with ongoing distress only among 'other' respondents. Both informal social connectedness and civic engagement were associated with lower probable PTSD scores for respondents in receipt of financial hardship support and 'other' respondents. Among Aboriginal respondents only, higher social media engagement was associated with lower levels of ongoing distress and probable PTSD. Participating in a larger range of activities (greater breadth of participation) was significantly associated with lower probable PTSD scores for both financial hardship and 'other' respondents.

Table 5. Kendall Rank Correlation Coefficients between social capital variables and mental health outcomes for each respondent group.

Social Capital Construct	Aboriginal Respondents (n = 67)				Financial Hardship Respondents (n = 287)				Other Respondents (n = 1534)			
	Ongoing Distress		PTSD		Ongoing Distress		PTSD		Ongoing Distress		PTSD	
Flood Exposure [#]	0.39	***	0.22	*	0.29	***	0.24	***	0.31	***	0.26	***
Community Participation												
Informal Social Connectedness	−0.04		−0.13		−0.01		−0.15	**	−0.06	*	−0.09	***
Civic Engagement	−0.04		−0.10		−0.001		−0.11	*	−0.03		−0.07	**
Social Media Engagement	−0.25	*	−0.25	*	−0.03		−0.06		0.01		−0.01	
Religious Engagement	0.04		−0.10		−0.03		−0.08		0.001		−0.04	
Political Participation	0.06		−0.01		0.04		−0.02		0.03		−0.01	
Breadth of Participation	−0.03		−0.18		−0.04		−0.11	*	−0.03		−0.09	***
Perceptions of Participation												
Enjoyment of time socialising	−0.24	*	−0.23	*	−0.08		−0.17	**	−0.14	***	−0.20	***
Sufficiency of time socialising	0.02		0.04		0.09		0.07		−0.01		0.01	
Personal Social Cohesion												
Sense of Belonging	−0.23	*	−0.38	***	−0.12	*	−0.29	***	−0.14	***	−0.17	***
Feeling of Belonging	−0.29	**	−0.42	***	−0.15	**	−0.35	***	−0.13	***	−0.21	***
Social Trust	−0.23	*	−0.34	**	−0.08		−0.18	**	−0.11	***	−0.14	***
Reciprocity—people try to help	−0.22		−0.39	***	−0.03		−0.17	**	−0.09	***	−0.11	***
Reciprocity—people look after themselves	0.18		0.27	*	0.03		0.004		0.05	*	0.08	***
Optimism	−0.21	*	−0.24	*	−0.19	***	−0.24	***	−0.16	***	−0.20	***

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; [#] Cumulative Exposure Index (CEI).

Higher levels of personal social cohesion were significantly associated with lower levels of probable PTSD in all respondent groups. Belonging and optimism were significantly associated with less ongoing distress for respondents in financial hardship. Similarly, these constructs, in addition to social trust, were associated with less ongoing distress for Aboriginal respondents (Table 5).

Tables 6 and 7 summarise the unweighted hierarchical logistic regression results across all three respondent groups for ongoing distress and probable PTSD at six months respectively (weighted analyses produced trivial and non-significant differences in estimates with identical patterns of associations, so are not presented here). There were no significant interactions detected at $p < 0.01$ between sociodemographic characteristics and flood exposure or social capital variables.

Table 6. Parameter estimates and associated statistics of multiple hierarchical logistic models predicting flood-related ongoing distress for each respondent group, controlling for sociodemographic factors ‡.

	Aboriginal Respondents (*n* = 66)				**Financial Hardship Respondents †** **(*n* = 280)**				**Other Respondents (*n* = 1477)**			
Model Block	**aOR**	**(95%CI)**	**Δ*D***	***D***	**aOR**	**(95%CI)**	**Δ*D***	***D***	**aOR**	**(95%CI)**	**Δ*D***	***D***
1. Flood Exposure (CEI)			0.22	0.29			0.10	0.11			0.13	0.14
	2.73	(1.52–4.91)	**^		1.86	(1.46–2.38)	*** ^		2.15	(1.90–2.42)	*** ^	
2. Community Participation												
2 A. Type & extent of participation											0.01	0.15
Informal Social Connectedness	-				-				0.86	(0.77–0.97)	*	
2 B. Perceptions of participation			0.05	0.34							0.01	0.16
Enjoy time spent socially	0.59	(0.37–0.95)	* ^		-				0.76	(0.67–0.87)	***	
3. Personal Social Cohesion							0.05	0.16			0.02	0.18
Sense of Belonging	-				-				0.81	(0.68–0.96)	* ^	
Optimism	-				0.62	(0.48–0.79)	*** ^		0.74	(0.64–0.86)	***^	

‡ Age, sex, education level, employment and relationship status; † In receipt of following income support: single parent payment, unemployment allowance, youth allowance, disability support, carer payment; D = Tjur's coefficient of discrimination; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ^ Predictor made an independent significant contribution in the third and final model; adjusted odds ratios (aORs) reported are for the model in which the predictors were added.

Table 7. Parameter estimates and associated statistics of multiple hierarchical logistic models predicting flood-related probable PTSD for each respondent group, controlling for sociodemographic factors ‡.

	Aboriginal Respondents (*n* = 67)				**Financial Hardship Respondents †** **(*n* = 283)**				**Other Respondents (*n* = 1463)**			
Model Block	**aOR**	**(95%CI)**	**Δ*D***	***D***	**aOR**	**(95%CI)**	**Δ*D***	***D***	**aOR**	**(95%CI)**	**Δ*D***	***D***
Socio-demographic Factors				0.12								0.02
Education (non-university level)	4.56	(1.12–18.60) *			-				1.68	(1.20–2.35) **		
Employment (not in employment)	-				-				2.08	(1.31–3.29) **		
Relationship status (single)	-				-				1.44	(1.02–2.05) *		
1. Flood Exposure (CEI)			0.07	0.19			0.07	0.09			0.10	0.12
	1.69	(1.06–2.72) *			1.63	(1.30–2.05) ***^			2.22	(1.91–2.58) ***^		
2. Community Participation												
2 A. Type and extent of participation			0.08	0.27			0.03	0.12			0.02	0.14
Informal Social Connectedness	0.53	(0.31–0.92) *			0.71	(0.56–0.89) **			0.72	(0.63–0.83) ***		
2 B. Perceptions of participation							0.04	0.16			0.04	0.18
Enjoy time spent socially	-				0.76	(0.61–0.95) *			0.60	(0.51–0.70) ***^		
Sufficient time socialising	-				1.30	(1.08–1.56) **			1.16	(1.02–1.32) *		
3. Personal Social Cohesion			0.18	0.45			0.09	0.25			0.06	0.24
Feeling of Belonging	0.41	(0.23–0.71) ** ^			0.48	(0.37–0.62) *** ^			0.65	(0.55–0.76) ***^		
Optimism	-				-				0.67	(0.55–0.81) ***^		

‡ Age, sex, education level, employment and relationship status; † In receipt of following income support: single parent payment, unemployment allowance, youth allowance, disability support, carer payment; D = Tjur's coefficient of discrimination; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; ^ Predictor made an independent significant contribution in the third and final model; adjusted odds ratios (aORs) reported are for the model in which the predictors were added.

3.1. Aboriginal Respondents

None of the socio-demographic factors for Aboriginal respondents made an independent contribution to explaining their 'still distressed' status six months after the flood. Higher levels of flood exposure were strongly associated with ongoing distress (aOR 2.73; 95% CIs: 1.52–4.91) and remained that way in the final model, explaining most model variance (change in Tjur's D = 22%) (Table 6). After adjusting for socio-demographic characteristics and flood exposure, social media engagement was not significantly associated with ongoing distress. While types of community participation were not significant in the model, enjoyment of participation was strongly associated with less distress (aOR 0.59; 95% CIs: 0.37–0.95). None of the personal social cohesion variables was independently significantly associated with ongoing distress for this respondent group.

Compared to ongoing distress, there were different patterns of association between flood exposure, social capital and probable PTSD for Aboriginal respondents (Table 7). Higher levels of educational attainment made a significant independent contribution to explaining lower probable PTSD scores. This variable became non-significant when flood exposure was added to the model. Flood exposure was associated with a higher risk of probable PTSD explaining a further 7% of the model. Greater informal social connectedness was significantly independently associated with lower PTSD risk, while perceptions about the quality and quantity of time spent with others did not further explain PTSD outcomes. The contribution of flood exposure and informal connectedness became non-significant with the addition of the social cohesion variables. Feelings of belonging (aOR 0.41; 95% CIs: 0.23–0.71) were strongly associated with lower levels of probable PTSD and explained most of the model variance (18%) for Aboriginal respondents.

In summary, in the final models, consistent with predictions in our flood impact framework, post-flood ongoing distress was explained in order of magnitude by greater levels of flood damage and lower scores of enjoying social participation. A greater risk of post-flood probable PTSD was mainly explained by lower feeling of belonging scores.

3.2. Respondents in Financial Hardship

Socio-demographic variables were not significantly associated with ongoing distress for respondents in financial hardship six months after the flood. Similar to Aboriginal respondents, higher levels of flood exposure were strongly associated with ongoing distress (aOR 1.86; 95% CIs: 1.46–2.38) explaining most of the model variance (10%) (Table 6). Neither type nor perceptions of community participation made any contribution to explaining ongoing distress. Greater optimism (aOR 0.62; 95% CIs: 0.48–0.79) was the only component of social cohesion that was significantly associated with lower levels of ongoing distress, explaining a further 5% of the variance in the model.

Similar to ongoing distress patterns of association, socio-demographic factors were not significantly associated with probable PTSD and greater flood exposure was strongly associated with a higher risk of probable PTSD (1.63; 95%CIs: 1.30–2.05) explaining 7% of the model variance (Table 7). In contrast to ongoing distress, informal social connectedness (aOR 0.71; 95% CIs: 0.56–0.89), enjoying participation (aOR 0.76; 95%CIs: 0.61–0.95) and having sufficient quantity of social time (aOR 1.30; 95% CIs: 1.08–1.56) were significantly associated with probable PTSD. Increased feelings of belonging (aOR 0.48; 95% CIs: 0.37–0.62) was the only social cohesion variable that was significantly associated with lower probable PTSD scores. The addition of feelings of belonging explained a further 9% of the variance and rendered the community participation indicators non-significant in the probable PTSD model.

As predicted, in the final models for respondents in financial hardship, post-flood distress was explained in order of magnitude by greater levels of flood exposure and lower optimism scores. Post-flood probable PTSD was explained in order of magnitude by greater flood exposure and lower feeling of belonging scores.

3.3. General Community Respondents

Socio-demographic variables for 'other' respondents were not significantly associated with ongoing distress six months after the flood (Table 6). As with both marginalised respondent groups, higher levels of flood exposure were strongly associated with reports of ongoing distress (aOR 2.15; 95% CIs: 1.90–2.42) explaining most variance in the model (13%). Unlike marginalised respondent groups, there was a significant association between higher levels of informal social connectedness and less distress (aOR 0.86; 95%CIs: 0.77–0.97). Similar to Aboriginal respondents, enjoying community participation was significantly associated with less ongoing distress for the general respondent group (aOR 0.76; 95% CIs: 0.67–0.87). Having a greater sense of belonging (perceived social supports) (aOR 0.81; 95% CIS: 0.68–0.96) and optimism (aOR 0.74; 95% CIs: 0.64–0.86) were also significantly associated with less distress. The contribution made by informal connectedness and enjoying community participation became non-significant when these social cohesion variables were added to the model.

Lower educational attainment, not being in paid employment and single relationship status made independent contributions to increasing the risk of probable PTSD for the general respondent group (Table 7). These demographic factors, however, became non-significant in subsequent model steps. Again, like both marginalised respondent groups, higher levels of flood exposure were strongly associated with probable PTSD (aOR 2.22; 95% CIs: 1.91–2.58). Unlike marginalised groups, however, flood exposure explained most variance in probable PTSD outcomes for general community respondents (10%). There were similar patterns of association between social capital variables and probable PTSD between the general respondent group and those in financial hardship. Higher informal social connectedness (aOR 0.72; 95% CIs: 0.63–0.83) and enjoying social participation (aOR 0.60; 95% CIs: 0.51–0.70) were significantly associated with lower probable PTSD scores. Wanting to spend more time with others (indicating a degree of social isolation; aOR 1.16; 95%CIs: 1.02–1.32) was significantly associated with an increased risk of probable PTSD. Of all community participation variables, only enjoyment of participation remained significant in the final model for 'other' respondents. Like marginalised groups, lower scores for feelings of belonging (aOR 0.65; 95% CI: 0.55–0.76) were associated with higher probable PTSD scores. In addition, however, greater optimism (aOR 0.67; 95% CI: 0.55–0.81) was also strongly associated with less PTSD symptomology for the general respondent group.

In summary, significant associations in the final models align with predictions in our *flood impact framework*. Post-flood distress was explained in order of magnitude by greater flood exposure and lower optimism and a sense of belonging scores (perceived availability of social supports). Post-flood probable PTSD was explained by greater flood exposure and lower quality of social participation, feelings of belonging and optimism scores.

4. Discussion

Broadly, our findings support the propositions that (i) the components of social capital may be causally related in that community participation may be an important contributor to the formation of social cohesion; and (ii) while exposure to a flood event harms mental health across the whole community, the mental health of those with more social capital is not as severely harmed as those with less social capital. We examined the relationship between social capital and mental health among Aboriginal, financially disadvantaged and other members of the general community six months following a severe flood event. As expected, the greater participants' exposure to the flood, the greater the likely harm to their mental health, particularly so for marginalised community members. Social capital played an important role in the degree of flood-related harm people reported in that those with higher levels of social capital reported less harm to their mental health than did those with less. However, the strength and nature of this effect varied by the group.

4.1. Aboriginal Respondents

With lower levels of informal social connectedness, belonging, social trust and optimism, Aboriginal respondents had less social capital than the general respondent group. These findings are in line with other social capital analyses in Aboriginal population-representative surveys [32,43,44]. As in previous studies, we found subtle differences in what mattered most for mental health and wellbeing compared to other respondent groups. Aboriginal respondents were like other groups in that individuals with greater feelings of belonging were less likely to experience post-flood PTSD. In contrast to other groups, optimism did not feature amongst the social cohesion factors that mattered most for Aboriginal respondents in terms of reducing the likelihood of ongoing distress.

Social capital and resilience can mean different things for different populations, suggesting that the way it is measured in the general Australian population may not adequately capture concepts of social participation and cohesion important to Aboriginal communities [32,45]. The community participation variables used in this study have been validated previously in an Australian Aboriginal community [6,30] and our study confirms the relevance of the participation variables (including social media engagement as a new type of participation) to Aboriginal participants. Yet, from an Aboriginal perspective, there are other characteristics of social relationships and resilience that are important in overcoming adversity. Relational identity is key, that is, the knowledge of and connection to one's own community, culture and Country [46]. Colonisation severely disrupted these connections, the impact of which is still acutely felt today. Land dispossession, social and cultural dislocation (including the destruction of languages) and systematic genocide (including the forced removal of children from their Aboriginal families) have led to inter-generational trauma with devastating consequences for social and emotional wellbeing. Systemic and interpersonal racism reinforces socio-economic exclusion and mistrust in mainstream institutions [44,45] and has been linked to depression in Aboriginal people [47]. Consequently, there are significant chronic disparities across socio-economic and health indicators between Aboriginal and non-Indigenous Australians. The active resistance by and survival of Aboriginal communities throughout history and against ongoing adversity speaks to their strength, resilience and determination. The cultural context of this resilience (strong familial links, connection to country, language and ceremony) is protective in the face of repeated tragedies that Aboriginal communities often experience [48,49] and our study provides further evidence of how this may operate in the face of natural disasters.

While a strong sense of shared identity and belonging (bonding capital) within Aboriginal communities is important for their resilience and wellbeing, there is complexity in the link between Aboriginal social capital and social mobility. In the general community, connecting to other groups with different social identities has the potential to help one 'get ahead' by making accessible new opportunities and resources [11]. To receive some form of mutual benefit in this way intrinsically involves trust and reciprocity with an expectation of some form of 'repayment' (the amount and timing of which is not fixed) [50]. Considering the historical and cultural contexts described above, the pursuit of broader linkages (bridging capital) for Aboriginal people may be limited where their trust in members of the general community is compromised and their within-community social capital may not be valued or have currency outside of their community due to racial prejudices [45].

Despite the importance of historical and cultural contexts, consideration of these contexts is not currently evident in the development of local-level disaster risk reduction strategies. Active and equal participation of and leadership by Aboriginal people has resulted in successful public health responses to entrenched domestic violence within a community [48] and in prioritising the safety of Aboriginal communities during the current COVID−19 pandemic [51], demonstrating the importance and effectiveness of culturally-led solutions to complex threats to health and wellbeing. In a similar way, there is a great opportunity for Aboriginal-led approaches to address disaster risk that would benefit the whole community. For instance, Caring for Country initiatives, where Aboriginal and Torres Strait Islander knowledge is used appropriately to care for traditional lands and seas, have continually demonstrated multiple social, cultural, ecological, economic and health

benefits [52–54]. These Aboriginal-led partnerships strengthen culture as well as enhance respect and appreciation of Aboriginal knowledge within mainstream populations [54]. By focusing on cultural context, strengthening connection to Country and increasing social networks, such initiatives will likely enhance feelings of belonging for Aboriginal people, a key driving factor influencing post-disaster distress.

A novel finding from this study is that social media may be a promising avenue for strengthening informal social connectedness for Aboriginal communities. Compared to the general community and those in financial hardship, Aboriginal respondents with higher social media usage were less likely to indicate post-flood distress and PTSD, perhaps because it increases social connectedness in this group. Previous research has shown social media use to be more common among Aboriginal compared to non-Indigenous people [55]. There is complexity in the relationship between the use of technology and social connectedness. Whether it enhances the quality of social relationships depends on the type of platform, motives for use and whether it is used actively or passively which, in turn, are influenced by socio-demographic characteristics [56,57]. In this study, the relationship between social media and distress for Aboriginal respondents was non-significant after controlling for socio-demographic characteristics, indicating that these characteristics may mediate the relationships. A more nuanced understanding is required to develop strategies to enhance its effectiveness in reducing isolation for this group. Social media can be an effective tool if used to strengthen existing relationships or initiate new meaningful ones (rather than as a substitute for real-life interaction) [57]. It may also be an effective vehicle for managing disaster risk and providing health messaging and education [55,58].

4.2. Respondents Living with Financial Disadvantage

Like Aboriginal community members, people living with financial disadvantage (as indicated in this study by being in receipt of certain types of government income support), had less social capital than general community members (including lower levels of informal social connectedness, civic engagement, belonging, social trust and optimism) supporting other research showing income inequality to be a consistent predictor of community participation [59], social isolation and sense of belonging [60].

Compared to general community members, those in financial hardship were more likely to be single, unemployed and have lower educational attainment levels. Quality of time spent socially and feelings of belonging were what mattered most for those in financial hardship with respect to probable PTSD outcomes. As a corollary, those wanting to increase the quantity of time spent socially (social isolation) were more likely to experience post-flood PTSD. Reasons for social isolation can be structural (i.e., lack of resources to enable access to social activities; lack of opportunity to access social networks otherwise available through education or employment); interpersonal (i.e., being avoided by others due to prejudice and discrimination); and personal (e.g., embarrassment, concern about stigmatisation or poor health) [60]. Because of these issues, people in financial hardship generally avoid social situations perceived as challenging, tending instead to socialise with others experiencing the same marginalisation. As a result, they generally have commensurately smaller and less reciprocal networks [60,61]. Places of belonging for the financially marginalised tend to be community support agencies or drop-in centres due to the economic and social support they provide. While relationships generated with service providers (e.g., providing food, housing, employment support, etc.) are beneficial, they are not spontaneous relationships but are 'deliberately constructed' and do not necessarily meet the social needs of marginalised people [61]. Similar to Aboriginal people, bonding social capital is an important buffer against poor mental health while lack of bridging social capital can be detrimental. For example, low-income individuals living in affluent areas can have worse mental health (exacerbated by social exclusion) compared to those living in deprived neighbourhoods [14,59].

People in financial hardship with greater optimism (a tendency to expect positive outcomes in the future), were less likely to experience ongoing distress. Optimists refuse to give up [62]. Instead, they tend to look for benefits in adversity and employ more effective coping strategies than

pessimists, making them more resilient to stressful events [63]. This is relevant to coping with a flood: optimism moderates the relationship between the level of household damage in a disaster and personal recovery [64]. Optimists' persistence in overcoming personal obstacles has also been attributed to their ability to forge bridging relationships across demographic and socio-economic divides [63]. In this study, greater informal social connectedness was related to greater optimism for people in financial hardship and associated with lower levels of ongoing distress. Resilience-building strategies for financially marginalised groups may benefit from interventions that build meaningful bridging relationships in environments that are safe and enjoyable from their perspective [6]. Such co-designed initiatives, preferably simultaneously addressing economic needs, will enhance agency and hope for the future [65].

4.3. Other Members of the General Community

Less optimistic members of the general community were more likely to show signs of post-flood distress and PTSD. This concurs with previous post-disaster research showing optimism reduces the likelihood of developing PTSD, suggesting a possible pathway to improve recovery and prevent adverse mental health impact [64]. General community members with a sense of belonging were also less likely to indicate long-term distress. It makes intuitive sense that post-disaster distress can be mitigated for individuals by turning to emotional, financial and social supports available through personal networks for recovery assistance. As for marginalised groups, greater feelings of belonging (the emotional evaluation of connectedness) decreased the likelihood of post-flood PTSD. Belonging is a fundamental human need [66]. There is a critical link between belonging and shared social identity and a belief that one's life is meaningful which is important for wellbeing across different social groups, particularly for those that experience systematic social exclusion [60,66].

4.4. Belonging and Inclusivity Make for a Resilient Future

Feelings of belonging that are enhanced, possibly created, by participation and social inclusion are key to alleviating post-flood distress for this diverse rural community. Belonging and shared identity are multifaceted, comprising our material possessions, immediate and extended social networks as well as the place we call home [67]. Receiving increasing attention in post-disaster recovery research is the psychology of place (incorporating social and geographical contexts) and the concept of 'solastalgia' [67–69]. In NSW rural communities, feelings of belonging and perceptions of one's environment are important for resilience [70]. Perhaps reflecting Aboriginal notions of connection to Country and its importance for wellbeing, solastalgia describes the sense of loss experienced by individuals when the surrounding environment changes to the extent that it no longer resembles home or becomes a place of danger in a disaster-prone area [68]. Extreme events that destroy homes and livelihoods or which force evacuation and long periods of displacement are known to exacerbate mental health issues, particularly for marginalised groups [27,67].

Given the complexity of social capital and the subtle variation in how it operates across different socio-economic groups, approaches to developing resilience strategies must involve the very groups for which they are designed. This analysis has pointed out key issues that may work to boost social connectedness for marginalised groups. In-depth qualitative research is required to fully understand the contextual and cultural factors that shape the specific needs of these different groups to jointly enhance participation and social cohesion for improved community adaptive capacity and disaster resilience. Compared to urban areas, rural communities tend to be known for high levels of some social capital (such as community participation and trust) but they can also have lower levels of tolerance for diversity, undermining their 'collective efficacy' [71]. So, while participatory approaches are critical, it is important that intervention strategies not be compartmentalised within social groups. Rather, we need to design strategies that consider broader contexts and are structured to be inclusive (e.g., interactions between social groups) to maximise the effectiveness of social capital interventions to strengthen overall community resilience.

4.5. Strengths and Limitations

Our sampling approach, while necessary to meet the goals of this study, constrains our ability to generalise our results to the broader population. Further, this is a self-report, cross-sectional design that limits our ability to untangle complex pathways to determine cause and effect and the presence of bi-directional relationships between social capital and mental health. Hence, our study design does not permit conclusions about whether social capital was directly protective against flood-related harm to mental health. Pre-existing mental health status may have biased responses and without pre-disaster community participation and social cohesion measures, we cannot be sure how the flood influenced social capital across the respondent groups.

While the proportion of Aboriginal respondents was close to the proportion living within Northern NSW, the small number of Aboriginal respondents reduced statistical power and may have led to the exclusion of meaningful predictors of flood-related distress. Where sample numbers were small, our analysis focused largely on the direction of associations and whether they were consistent with our expectations of the relationships between social capital, flood exposure and psychological distress. Our results were consistent with other studies investigating Aboriginal and Torres Strait Islander social capital [32,43,44] and can usefully inform future research with this population in the co-design of disaster risk reduction strategies. While validation studies of the Australian Community Participation Questionnaire and feelings of belonging included an Aboriginal community [6,32], our other social capital measures have been wholly designed and validated within so-called Western populations and may not adequately represent the experiences of other cultural groups. We also recognise that social capital for groups cannot be understood in isolation, but as part of an interacting set of capitals within the community that encapsulates human (knowledge, skills, the health of individuals), natural (land, water and biological resources), physical (infrastructure, equipment and technological resources) and financial (income, savings, credit, etc.) dimensions that also influence the adaptive capacity of rural communities [72].

Despite these limitations, our findings are consistent with our expectations and with other studies that have used population-representative samples and other study designs. We aimed to use a theoretically-driven approach to describe and quantify the relationships between flood impact, social capital and mental health with a particular focus on comparing the experiences of different types of community members. Using directly flood-related measures of mental health and adjusting for a very wide range of relevant socio-demographic controls, we found support for our proposition that social interactions, supports and cohesion are important in mitigating distress related to the flood.

A particular strength of our study was the close engagement with the community which led to our pragmatic, purposeful sampling approach that enabled measurement of these theoretical relationships for diverse, vulnerable sub-population groups. The CAGs continued to meet regularly over a period of 18 months during which findings were shared and interpretative discussions held to inform report writing and the dissemination of findings [21]. The aim of the community-academic partnership was to undertake useful research and disseminate findings addressing community-driven information needs. Our theories were supported by the findings which provide new insights on the development of local public health and disaster management policies aimed at strengthening dimensions of social capital to reduce post-disaster mental health. With Northern NSW being a flood-prone area [24], it is inevitable that this region will experience similar disasters in the future. There is a pressing need therefore to strengthen community social capital collectively through co-designed strategies that simultaneously address social and economic exclusion, cultural needs and environmental restoration. Multiple benefits for the community will ensue: reduced inequities; strengthened psychological well-being and resilience; lessened risk of long-term personal distress from disaster events; and reduced need for expensive individual psychological interventions [73] which are inequitably available and accessed [74,75].

5. Conclusions

Following the 2017 Northern NSW flood, Aboriginal and financially disadvantaged respondents reported lower levels of social capital (informal social connectedness, feelings of belonging, trust and optimism) compared to general community participants. Despite this, informal social connectedness and belonging were important factors for all participant groups and were associated with reduced risk of ongoing distress and PTSD.

Although it is well established that social capital is vital to promoting and maintaining positive mental health and wellbeing, there is relatively little research on how social capital influences psychological outcomes from weather-related disasters and, specifically, for marginalised population groups. Our study has deconstructed social capital to highlight what matters most for socio-economically marginalised groups to inform tailoring of safe and effective resilience-building strategies. Access to social capital is not homogeneous, with various groups subject to differential barriers in building and benefitting from social capital and its benefits to mental wellbeing. Community-level interventions are required tailored to specific groups through participatory processes. Future studies will be able to further disentangle these concepts, especially with regard to cause and effect, and to study how social capital operates in broader community contexts: which social resources benefit health for individual groups; and which characteristics of the wider social environment may promote such benefits.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Appendix A.1. Brief Weather-Related Disaster Trauma Exposure and Impact Screen

Development and Source

Construction of the Brief Weather-related Disaster Trauma Exposure & Impact Screen occurred in 2009 and was based on Australian research with adults [76] and a body of Australian research on post-natural disaster PTSD in children and adolescents [19,77]. The measure was field-tested and deployed as part of the Queensland Government's annual Self-Reported Health Status survey following severe flooding in the summer of 2010–2011.

A more detailed summary of the derivation of items follows:

Item	Derivation
A weather disaster (e.g., flood, bushfire, storm, cyclone) damage or destroy your home.	Adapted from 'trauma exposure' items in McDermott et al. [19,77]: 'experienced damage to [your] home, including broken windows, damage to part or all of [your] roof or other home damage'. Exposure to the traumatic event (i.e., witnessing actual flames) and proxy measures of exposure such as home damage, are significant predictors of adverse emotional outcomes in all published predictive models.
Did any of the following happen as a result of this weather-related disaster?(a) You thought you might die	Adapted from O'Donnell [76], item #6 from the final ten-item measure, p.929, 'During the event, I thought I was about to die'; and adapted from McDermott et al. [19,77]. In the latter research, of all measured variables, threat perception had the strongest relationship with post-disaster post-traumatic stress disorder.
(b) You personally knew people who were killed or badly injured.	Adapted from O'Donnell [76], item #6 from the original list of peri-trauma items, *p*.926, 'I witnessed other people being killed or injured'; and adapted from McDermott et al. [19,77], perceived threat of death to self and perceived threat of death to parents (for children and adolescents).
(c) You felt terrified, helpless or hopeless.	Consistent with diagnostic criteria (A2) for PTSD (DSMIV) and ICD entry criteria. Adapted from O'Donnell [76], item #5 from the final ten-item measure, p.929, 'At the time of the event, I felt terrified, helpless or hopeless'.
(d) You are still currently distressed about it.	Allows calculation of point prevalence of post-disaster distress and differentiation from other possible causes of anxiety; can be validated against related constructs measured in the same survey. This item provides insight into whether ongoing stress and anxiety are directly related to the traumatic event (in addition to any relationships we may find with other measures of health and wellbeing).

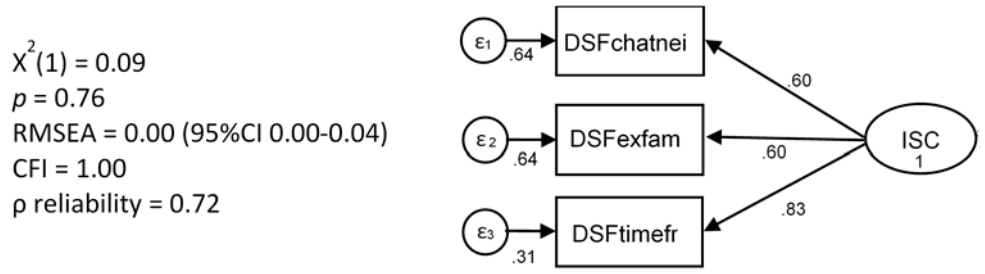
Appendix B

Confirmatory Factor Analysis of Social Capital Constructs within the Northern Rivers Community Recovery after Flood Survey (n = *2046)*

Informal Social Connectedness (ISC: chat with neighbours, make time to keep in touch with friends, spend time with extended family members).

All items loaded significantly ($p < 0.001$) and strongly on a single ISC dimension (Table A1). The fit statistics indicated model saturation (or best possible fit). There was no significant difference in the path coefficients for a chat with neighbours and spend time with extended family, so these loadings were constrained to be equal. The resulting scale reliability was $\rho = 0.72$.

The factor score weights (Figure A1) calculated for use in regression analyses refers to the predicted value the latent variable ISC increases by with a one-unit increase in the agreement scores from respondents relating to ISC activities. For example, a one-unit increase in scores measuring agreement with 'I make time to keep in touch with my friends' is predicted to increase their informal social connection score by 0.457 units.

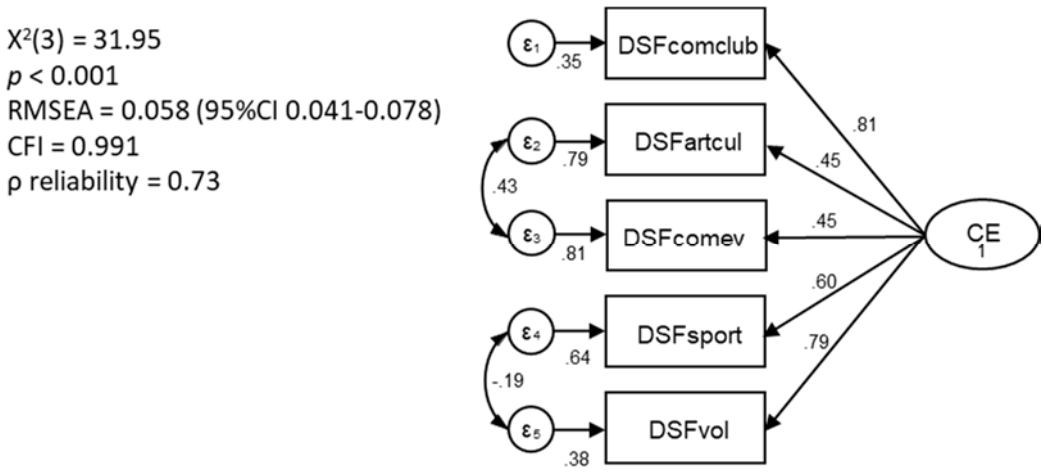


Factor Score Weights	DSFtimefr	DSFexfam	DSFchatnei
ISC	0.457	0.11	0.22

Figure A1. Final model for Informal Social Connectedness constructs of community participation.

Civic Engagement (CE: I go to arts and culture events, I attend community events, I volunteer locally, I take part in sports activities or groups, I take part in community-based clubs or association, I attend worship services or go to prayer meetings).

Attendance at worship services item was removed from the CE construct as it loaded weakly (standardised loading 0.22; $p < 0.001$) and correlated poorly with other items (polychoric $\rho < 0.2$). The remaining five items all loaded significantly and strongly, but the fit of the initial model was not satisfactory: $\chi^2(5) = 770.57$, $p < 0.001$, RMSEA = 0.274 (95%CIs:0.257–0.290), CFI = 0.76. After analysis of modification indices (which provides estimates of how much the chi-squared will be reduced if we changed the model by estimating extra parameters), we correlated the error terms for attending arts & culture events (DSFartcul) & community events (DSFcomev) items. This made conceptual sense as they are similar in terms of the 'passive' nature of attending events compared to the more 'active' items within this construct, such as volunteering and taking part in different activities. It also made conceptual sense to correlate the errors between volunteering (DSFvol) and participating at local sporting clubs (DSFsport) since these may co-occur, e.g., coaching or officiating matches. There was no significant difference in the path coefficients for attending arts & culture and community events, so these loadings were constrained to be equal. Following these changes, we obtained a satisfactory fit (Figure A2). All five items have a substantial loading (range: 0.45 to 0.81) that are significant at the $p <$ 0.001 level. The resulting scale reliability was $\rho = 0.73$.

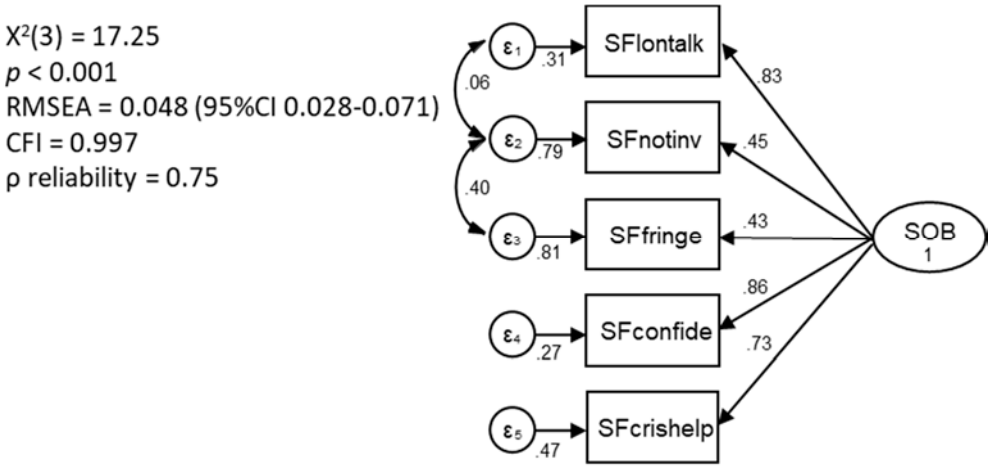


Factor Score Weights	DSFcomclub	DSFartcul	DSFcomev	DSFsport	DSFvol
CE	0.193	0.041	0.018	0.182	0.262

Figure A2. Final model for Civic Engagement constructs of community participation.

Sense of belonging (When I feel lonely there are several people I could call and talk to, I don't often get invited to do things with others, I feel that I'm on the fringe in my circle of friends, I have family or friends I can confide in, There are people outside my household who can offer help in a crisis).

This construct represents the cognitive aspect of belonging, i.e., self-categorisation as belonging to a group through which social supports are available for connecting, confiding and seeking help. The five items all loaded significantly and strongly, but the fit of the initial model was not satisfactory: $\chi^2(5) = 595.00$, $p < 0.001$, RMSEA = 0.240 (95%CIs:0.224–0.257), CFI = 0.857. Substantial modification indices indicated a correlation of errors between often not getting invited to do things with others (SFnotinv) and feeling on the fringe of friendship groups (SFfringe) and also between having several people to call if feeling lonely (SFlontalk) and often not getting invited to do things with others (SFnotinv). These items are part of the 'Belonging' subscale of the Interpersonal Support Evaluation List (ISEL) designed to measure the perceived availability of people to interact with [34]. Correlating these error terms improved our fit (Figure A3), and all were significant at the $p < 0.001$ level. All five indicators of SOB had substantial loadings (range: 0.43 to 0.86). Scale reliability was ρ = 0.75.



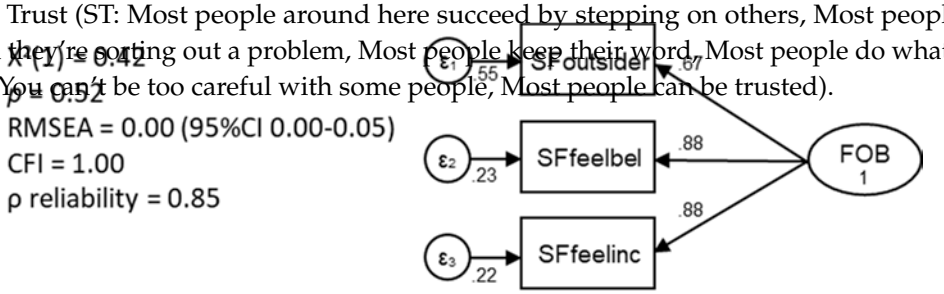
Factor Score Weights	SFlontalk	SFnotinv	SFfringe	SFconfide	SFcrishelp
SOB	0.297	0.094	0.168	0.369	0.200

Figure A3. Final model for Sense of Belonging construct of personal social cohesion.

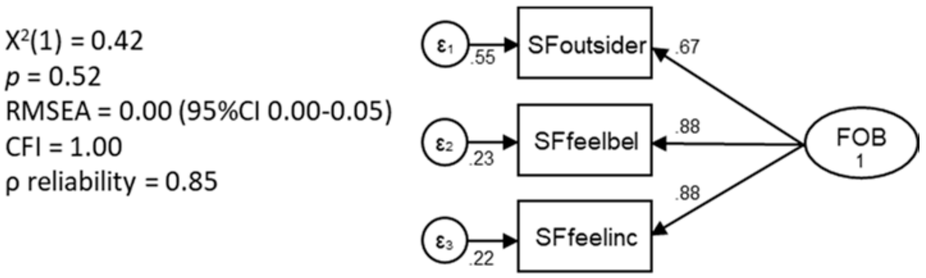
Feelings of Belonging (FOB: I feel like an outsider, I feel included, I feel that I belong)

This construct represents the affective aspect of belonging, i.e., a person's emotional evaluation of social connectedness. All three items loaded significantly ($p < 0.001$) and strongly and the fit statistics indicated model saturation or best possible fit. As there was no significant difference in the path coefficients for feeling included and feeling of belonging, these loadings were constrained to be equal. The standardized loadings ranged from 0.67 to 0.88 and the resulting scale reliability was ρ = 0.85 (Figure A4).

Social Trust (ST: Most people around here succeed by stepping on others, Most people tell the truth when they're sorting out a problem, Most people keep their word, Most people do what they say they'll do, You can't be too careful with some people, Most people can be trusted).



This construct represents the affective aspect of belonging, i.e., a person's emotional evaluation of social connectedness. All three items loaded significantly ($p < 0.001$) and strongly and the fit statistics indicated model saturation or best possible fit. As there was no significant difference in the path coefficients for feeling included and feeling of belonging, these loadings were constrained to be equal. The standardized loadings ranged from 0.67 to 0.88 and the resulting scale reliability was ρ = 0.85 (Figure A4).

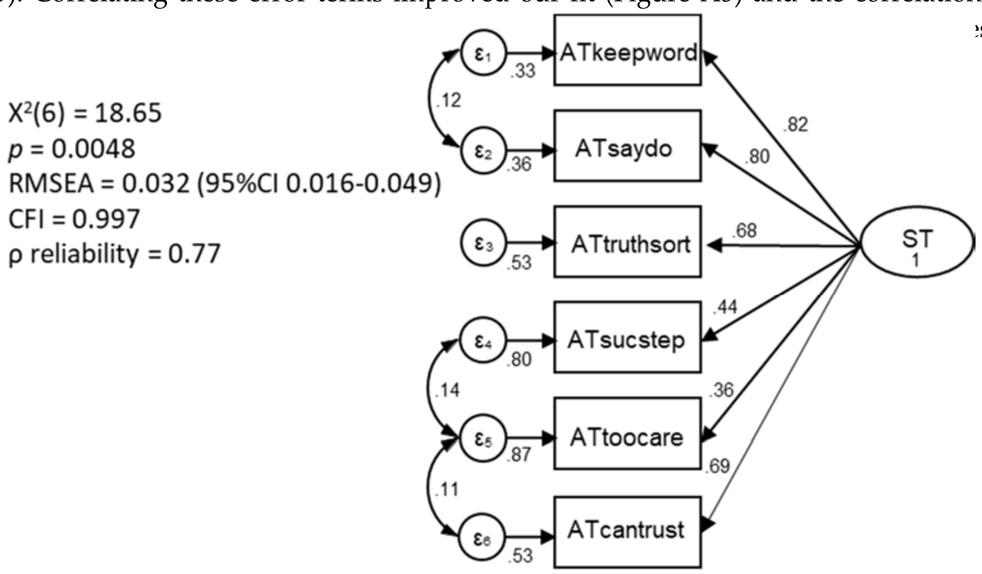


Factor Score Weights	SFoutsider	SFfeelbel	SFfeelinc
FOB	0.115	0.36	0.342

Figure A4. Final model for Feelings of Belonging construct of personal social cohesion.

Social Trust (ST: Most people around here succeed by stepping on others; Most people tell the truth when they're sorting out a problem; Most people keep their word; Most people do what they say they'll do; You can't be too careful with some people; Most people can be trusted).

All six items loaded significantly, but had poor model fit $\chi^2(9) = 192.74$, $p < 0.001$, RMSEA = 0.100 (95% CI: 0.088–0.112), CFI = 0.958. Following analysis of modification indices, we correlated error terms between 'most people keep their word' (ATkeepword) and 'most people do what they say they'll do' (ATsaydo) items from the Krupat 'Community Attachment' dimension of the Organizational Trust Inventory (OTI) [37]; the two World Values Survey items ('you can't be too careful with some people'—ATtoocare and 'most people can be trusted'—ATcantrust) [35] and ATtoocare and the third OTI item about people taking excessive advantage of others ('most people around here succeed by stepping on others'—ATsucstep). Correlating these error terms improved our fit (Figure A5) and the correlations were significant at the $p < 0.001$ level. Standardised loadings ranged from 0.36 to 0.82 and the resulting scale reliability was ρ = 0.77.



Factor Score Weights	ATkeepword	ATsaydo	ATsucstep	ATtruthsort	ATcantrust	ATtoocare
ST	0.249	0.222	0.198	0.168	0.167	0.028

Figure A5. Final model for Social Trust construct of personal social cohesion.

Trait Optimism (OPT: Overall, I expect more good things to happen to me than bad; In uncertain times, I always expect the best; If something can go wrong for me, it will; I'm always optimistic about my future).

All four items loaded significantly and strongly on the trait optimism (OPT) dimension, and the fit of the model was reaching adequacy $\chi^2(2) = 30.76$, $p < 0.001$, RMSEA = 0.084 (95% CI: 0.059–0.110), CFI = 0.992. Following analysis of modification indices, we correlated error terms between 'always expecting the best' (WEexbest) and 'always optimistic about my future' (WEopt); the positively framed items from the Life Orientation Test – Revised [38]. Correlating these error terms improved the adequacy of fit (Figure A6) and the correlation was significant at the $p < 0.001$ level. All four indicators of OPT had substantial standardised loadings (range: from 0.55 to 0.88). The resulting scale reliability was ρ = 0.82.

Trait Optimism (OPT: Overall, I expect more good things to happen to me than bad; In uncertain times, I always expect the best; If something can go wrong for me, it will; I'm always optimistic about my future).

All four items loaded significantly and strongly on the trait optimism (OPT) dimension, and the fit of the model was reaching adequacy: $\chi^2(2) = 30.76$, $p < 0.001$, RMSEA = 0.084 (95%CIs:0.059–0.111), CFI = 0.992. Following analysis of modification indices, we correlated errors between 'always expecting the best' (WEexbest) and 'always optimistic about my future' (WEopt); the positively framed items from the Life Orientation Test – Revised [38]. Correlating these error terms improved the adequacy of fit (Figure A6) and the correlation was significant at the $p < 0.001$ level. All four indicators of OPT had substantial standardised loadings (range: from 0.55 to 0.88). The resulting scale reliability was ρ = 0.82.

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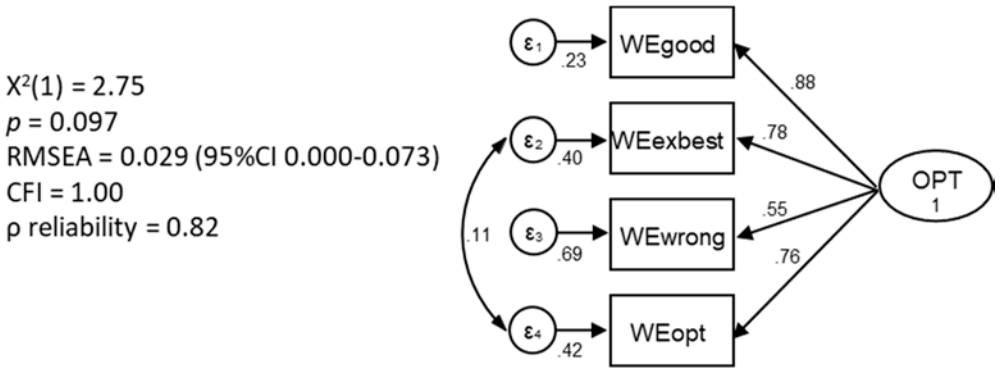
the best' (WEexbest) and 'always optimistic about my future' (WEopt); the positively framed items from the Life Orientation Test – Revised [38]. Correlating these error terms improved the adequacy of fit (Figure A6) and the correlation was significant at the $p < 0.001$ level. All four indicators of OPT had substantial standardised loadings (range: from 0.55 to 0.88). The resulting scale reliability was ρ = 0.82.



Factor Score Weights	WEgood	WEexbest	WEwrong	WEopt
OPT	0.452	0.200	0.275	0.185

Figure A6. Final model for Trait Optimism construct of personal social cohesion.

Figure A6. Final model for Trait Optimism construct of personal social cohesion.

Table A1. Comparison of CFA standardised factor loadings and model fit indices in Stata15 and Amos 25.

Construct		Stata		Amos #	
Informal Social Connection	x1: I make time to keep in touch with my friends	0.83	***	0.79	
	x2: I chat with my neighbours when I see them	0.60	***	0.62	***
	x3: I spend time with extended family members (relatives who don't live with me)	0.60	***	0.49	***
	RMSEA (95% CIs)	0.000(0.000–0.040)		0.071(0.030–0.119)	
	CFI	1.000		0.963	
Civic Engagement	x1: I take part in community-based clubs or associations (e.g., Rotary, CWA, book club, Lions)	0.81	***	0.63	
	x2: I go to arts or cultural events	0.45	***	0.34	***
	x3: I attend community events such as farmers' markets, festivals and shows	0.45	***	0.38	***
	x4: I take part in sports activities or groups	0.60	***	0.53	***
	x5: I volunteer locally (e.g., Meals on Wheels, school fete, Rural Fire Service)	0.79	***	0.66	***
	RMSEA (95% CIs)	0.058(0.041–0.078)		0.044(0.018–0.073)	
	CFI	0.991		0.989	
Sense of Belonging	x1: When I feel lonely there are several people I could call and talk to	0.83	***	0.78	
	x2: I have family or friends I can confide in	0.86	***	0.79	***
	x3: I feel that I'm on the fringe in my circle of friends (reverse scored)	0.43	***	0.34	***
	x4: I don't often get invited to do things with others (reverse scored)	0.45	***	0.35	***
	x5: There are people outside my household who can offer help in a crisis	0.73	***	0.67	***
	RMSEA (95% CIs)	0.048(0.028–0.071)		0.025(0.000–0.055)	
	CFI	0.997		0.999	
Feelings of Belonging	x1: I feel like an outsider (reversed scored)	0.67	***	0.67	
	x2: I feel that I belong	0.88	***	0.85	***
	x3: I feel included	0.88	***	0.85	***
	RMSEA	0.000(0.000–0.050)		0.000(0.000–0.067)	
	CFI	1.000		1.000	

Table A1. *Cont.*

Construct		Stata		Amos [#]	
Social Trust	x1: Most people keep their word	0.82	***	0.79	
	x2: Most people do what they say they'll do	0.80	***	0.78	***
	x3: Most people around here succeed by stepping on others (reverse scored)	0.44	***	0.32	***
	x4: Most people tell the truth when they're sorting out a problem	0.68	***	0.66	***
	x5: You can't be too careful with some people	0.36	***	0.34	***
	x6: Most people can be trusted	0.69	***	0.66	***
	RMSEA (95% CIs)	0.032(0.016–0.049)		0.011(0.000–0.036)	
	CFI	0.997		0.998	
Trait Optimism	x1: Overall, I expect more good things to happen to me than bad	0.88	***	0.85	
	x2: In uncertain times, I always expect the best	0.78	***	0.74	***
	x3: If something can go wrong for me, it will (reversed scored)	0.55	***	0.44	***
	x4: I'm always optimistic about my future	0.76	***	0.72	***
	RMSEA (95% CIs)	0.029(0.000–0.073)		0.000(0.000–0.067)	
	CFI	1.000		1.000	

[#] Gaskin, J. & Lim, J. (2018), "Merge SRW Tables", AMOS Plugin; *** $p < 0.001$; RMSEA—Root Mean Square Error of Approximation; CFI—Comparative Fit Index.

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Abstract

In 2017, areas of northern New South Wales experienced significant flooding as a result of ex-Tropical Cyclone Debbie. Such events are likely to become more frequent and severe due to climate change. There is a current gap in the literature investigating the effects of indirect disruption caused by flooding (e.g. loss of access to health and social care for people who have not had their property inundated) on mental health. A survey was conducted of flood-affected communities across northern New South Wales six months after the event to investigate relationships between the flood and adverse mental health outcomes. Responses were used to investigate associations between indirect disruptions and psychological morbidity. Respondents who reported indirect disruption were significantly more likely to report experiences consistent with probable post-traumatic stress disorder than those who did not report any disruption. Those who reported a loss of health and social care or a disruption to their utilities were more likely to experience adverse mental health outcomes. This study showed that indirect disruption due to flooding is associated significantly with adverse mental health. Post-disaster recovery managers might consider allocating mental health support for people who have experienced indirect disruptions.

Disruptions and mental-health outcomes following Cyclone Debbie

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Introduction

Recent years have seen a growing literature on the mental health and wellbeing of individuals affected by flooding (Fernandez *et al.* 2015). Much of the focus has been on the relationship between direct disruption due to flooding and poor mental health (Alderman, Turner & Tong 2012; Zhong *et al.* 2018; Waite *et al.* 2017; Jermacane *et al.* 2018; Reacher *et al.* 2004; Paranjothy *et al.* 2011; Fontalba-Navas *et al.* 2017; Milojevic *et al.* 2011). Inundation of property, damage to possessions and forced evacuations due to flooding can all be classified as direct disruptions. A key finding regarding direct disruptions has been their significant association with post-traumatic stress disorder (PTSD) (Waite *et al.* 2017; Munro *et al.* 2017; Jermacane *et al.* 2018; Zhong *et al.* 2018; Alderman, Turner & Tong 2013; Paranjothy *et al.* 2011; Matthews *et al.* 2019)

Conversely, there is a dearth of published research investigating the associations between mental health morbidity and *indirect* disruptions such as losing access to health care, food or place of employment for people who have not had their property inundated with flood water. Two of the only studies of indirect disruptions following flooding events come from England. These studies identified adverse effects on mental health, especially PTSD (Paranjothy *et al.* 2011, Waite *et al.* 2017). To date, there has been no research on the mental health effects of indirect disruptions published in the Australian context.

Objectives

The objectives of this research:

- Examine the associations between an experience of indirect disruption and direct disruption with mental health outcomes after a flood.
- Examine which types of indirect disruption due to flooding are most strongly associated with adverse mental health outcomes.

Study design

From September to November 2017, six months after ex-Tropical Cyclone Debbie caused extensive flooding

in northern New South Wales, a cross-sectional survey was implemented targeting people who had been living in six local government areas of Ballina Shire, Tweed Shire, Richmond Valley, Kyogle, Byron Shire and Lismore City at the time of the flood. These areas had an estimated population of 247,000 (Australian Bureau of Statistics 2017). Community members aged 16 years and older were recruited using a 'snowball' sampling method. This method incorporated social and organisational networks of local government authorities, business groups and community organisations and was supplemented by an extensive local advertising campaign using print, broadcast and social media. This included a leaflet drop in the two largest centres of population flooded; Lismore and Murwillumbah. All residents were encouraged to participate whether or not they felt the flood had affected them. The survey was available in online and paper formats. Potential respondents were advised that completion of the questionnaire would signify consent to participate in the study. A detailed description of the study design was published by Longman and colleagues (2019).

The study was approved by the University of Sydney Human Research Ethics Committee (reference-2017/589) and the Aboriginal Health and Medical Research Council Human Research Ethics Committee (reference-1294/17).

Measures of disruption

The survey contained questions relating to the degree of flooding, disruption, socio-demographic characteristics and the mental health and wellbeing of the respondents. Using the responses to the disruption questions, participants were categorised into three independent groups: directly disrupted, indirectly disrupted and non-disrupted (Waite *et al.* 2017).

Directly disrupted respondents: Those who reported flooding or damage to any area of their home or income-generating property (e.g. business or farm). These respondents had answered yes to at least one of the following questions:

- *Were non-livable areas of your home damaged or flooded (e.g. garage, garden shed)?*
- *Was at least one livable room in your home damaged or flooded (e.g. bedroom, living room, kitchen, bathroom)?*
- *If you own a business, was it damaged or flooded (e.g. if you own a shop, farm, warehouse)?*

Indirectly disrupted respondents: Those who were not flooded (i.e. answered 'No' to all the previous questions) but who answered yes to any of the following:

- *Your access to health and social care was disrupted.*
- *You had difficulty getting the food supplies you needed.*
- *You were temporarily isolated as surrounding roads were cut.*
- *You were unable to travel to your place of education (e.g. school, university, TAFE).*
- *There were interruptions to your household utilities (e.g. electricity, gas, drainage, septic).*
- *Your Wi-Fi/internet stopped working.*
- *You were unable to travel to your place of employment.*

Non-disrupted respondents: Those who reported none of the specified disruptions.

Measures to assess mental health

Previous studies of natural disasters including flooding have indicated that PTSD, depression, anxiety and increased suicide risk are common sequelae (Alderman, Turner & Tong 2013; Paranjothy *et al.* 2011; Waite *et al.* 2017; Zhong *et al.* 2018; Tang *et al.* 2018; Lowe *et al.* 2019). Therefore, in this study, mental health status was assessed using brief versions of validated screening tools of:

- the Patient Health Questionnaire (PHQ-2) for depression (Kroenke, Spitzer & Williams 2003)
- the Generalised Anxiety Disorder scale (GAD-2) (Kroenke *et al.* 2007)
- the Post Traumatic Stress Disorder Checklist (PCL-6) (Lang & Stein 2005, Fernandez *et al.* 2015).

The PHQ-2, GAD-2 and PCL-6 were selected to keep the outcomes of this study in-line with the only other study previously published investigating the comparison between disruption type due to flooding and adverse mental health outcomes (Waite *et al.* 2017).

Cut-points for probable diagnosis were ≥3 for the PHQ-2 and GAD-2 and ≥14 for the PCL-6 (Lang & Stein 2005; Kroenke, Spitzer & Williams 2003; Kroenke *et al.* 2007). To relate responses to the PCL-6 to the flood, the checklist was introduced as a list of complaints that people express after extreme rain and flooding. Additional mental health measures included an indicator of suicidal ideation from the Screening Tool for Assessing Risk of Suicide (Hawgood & DeLeo 2017) and an indicator of continuing distress six months after the flood (Clemens *et al.* 2013).

Socio-demographic measures

Socio-demographic data included age, gender, Indigenous status, relationship status, education level, employment status and government income support status. Only respondents with complete socio-demographic data were included in the analysis.

Analysis by disruption category

The analysis was conducted in two stages. First, binary logistic regression models were constructed to calculate the odds of experiencing each of the five types of mental health outcomes: continuing distress, suicidal ideation, probable depression, anxiety and PTSD. Respondents who did not complete a particular health outcome measure were excluded from analysis for that outcome. The dependent variables were the category of disruption, with non-disruption as the reference group. The models were adjusted for all measured socio-demographic characteristics. Sensitivity analyses were conducted to assess the level of bias introduced by including these characteristics.

Analysis by type of indirect disruption

In the second stage of the analysis, five multivariate logistic regression models were constructed that considered the

association between each type of indirect disruption with each of the five mental health conditions as an outcome.

It was reasoned that a substantial portion of participants who experienced an indirect disruption was likely to also have experienced direct disruption. Therefore, only analysing the participants who experienced an indirect disruption without direct disruption would have resulted in a markedly reduced sample from which conclusions could be drawn and could introduce risk of bias in the results. For this reason, every participant who reported an indirect disruption was included and participants were not grouped by disruption category. To account for potential confounding caused by experiencing both direct and indirect disruption, the regression models included a binary variable that indicated any experience of direct disruption by the participants. Again, each model was adjusted for socio-demographic characteristics.

The interest was in identifying significant associations and important confounders. As such, purposeful selection was employed to construct the multivariate logistic regression models. Consistent with the purposeful selection method, other indirect disruptors were retained in the model if they demonstrated a *p*-value of less than 0.15 or if they demonstrated significant confounding effects ($\Delta\beta > 20\%$) (Bursac *et al.* 2008). As there were multiple analyses investigating the mental health outcomes in both sets of analyses, the α for significance testing was set conservatively at 0.01. Every regression model produced in this study was tested for effect modifications (α=0.01). Stata 15 (Stata/SE 15.1 for Windows) was used for all statistical analyses.

Results

Respondent characteristics

In total, 2530 people responded to the survey and 350 (14 per cent) of the responses were missing socio-demographic data. Therefore, the analysis conducted using socio-demographic data was performed using a sample of 2180 participants. Negligible dissimilarities in parameter estimates and patterns of results were found between the full dataset and the dataset absent of missing socio-demographic records.

Mental health outcomes by disruption category

Of these 2180 respondents, 105 could not be classified into disruption categories due to incomplete survey responses, 242 respondents were classified as non-disrupted, 605 were classified as indirectly disrupted and 1228 were classified as directly disrupted. In total, 2075 respondents were included in this part of the analysis. Most of the respondents were over 45 years of age, were female, in a relationship and employed (Table 1, Appendix 1).

Among those who were classified as directly disrupted, between 10 per cent and 33 per cent demonstrated evidence of mental health distress in the outcomes measured. By comparison, among those who were classified as non-disrupted, between 2 and 8 per cent reported mental health distress (Table 2).

Accordingly, the differences in proportions demonstrating evidence of mental health distress between the two groups ranged from 7 per cent (suicidal ideation) to 25 per cent (still distressed).

The differences in proportions demonstrating evidence of mental health distress between those classified as indirectly disrupted and non-disrupted was less stark, ranging from 1 per cent (suicidal ideation) to 7 per cent (probable anxiety).

When factoring in potential confounders in the logistic regression model, the greatest effect on the odds of probable PTSD was found in respondents who experienced direct disruption (OR: 14.4; 95 per cent, CI 5.9–35.3) (Table 3). After adjusting for socio-demographic factors, probable PTSD remained strongly associated with direct disruption (OR:13.5; 95 per cent, CI: 5.5–33.4). Indeed, the odds of experiencing every mental health outcome remained significantly elevated in response to direct disruption after adjusting for socio-demographic factors (Table 3).

Respondents categorised as indirectly disrupted were significantly more likely to experience probable PTSD, probable anxiety or still feel distressed than those who were categorised as non-disrupted. After adjusting for socio-demographic factors, only the odds of probable PTSD remained significantly elevated (OR: 3.52, 95 per cent, CI: 1.36–9.15) (Table 3).

Mental health outcome by indirect disruption type

The relationships between each mental health outcome and each of the indirect disruption types were also examined using multivariate logistic regressions (n=2180).The other indirect disruptions were added to the models according to the purposeful selection method and were also adjusted for any experience of direct disruption and socio-demographic factors.

Loss of access to social or health care was shown to significantly increase the odds of every outcome except probable depression. No individual disruption type significantly influenced the odds of having probable depression (Table 5). On the outcome of probable anxiety, employment status significantly modified the size of the effect of a loss of access to health and social care. Among those participants who experienced a loss of access to health and social care, unemployed participants demonstrated greater odds of probable anxiety than those who were employed (OR: 2.67; 95 per cent, CI: 1.64, 4.35 vs OR: 1.05; 95 per cent, CI: 0.67, 1.64, respectively). A loss of utilities was strongly associated with every mental health outcome although this effect was only statistically significant for probable PTSD (OR: 1.9, 95 per cent, CI: 1.41–2.56) (Table 5).

Discussion

The strong link between disruption after a flood event and PTSD has been clearly elucidated in recent literature (Fontalba-Navas *et al.* 2017, Zhong *et al.* 2018, Dai *et al.* 2017, Waite *et al.* 2017, Paranjothy *et al.* 2011, Fernandez *et al.* 2015, Matthews *et al.* 2019). Consistent with Waite and co-authors (2017), these results

Table 1: Socio-demographic characteristics of respondents by disruption category.

Demographic		Disruption Category			
		No disruption	Indirectly	Directly	Total
Age (years)	16 to 25	8 (3%)	37 (6%)	65 (5%)	110 (5%)
	24 to 45	51 (21%)	173 (29%)	290 (24%)	514 (25%)
	45 to 65	115 (48%)	296 (49%)	667 (54%)	1078 (52%)
	65 and older	68 (28%)	99 (16%)	206 (17%)	373 (18%)
	Total	**242 (100%)**	**605 (100%)**	**1228 (100%)**	**2075 (100%)**
Gender	Female	163 (67%)	430 (71%)	834 (68%)	1427 (69%)
	Male	79 (33%)	175 (29%)	394 (32%)	648 (31%)
	Total	**242 (100%)**	**605 (100%)**	**1228 (100%)**	**2075 (100%)**
Aboriginal or Torres Strait Islander peoples	Yes	9 (4%)	14 (2%)	53 (4%)	76 (4%)
	No	233 (96%)	591 (98%)	1175 (96%)	1999 (96%)
	Total	**242 (100%)**	**605 (100%)**	**1228 (100%)**	**2075 (100%)**
Relationship status	In a relationship	162 (67%)	414 (68%)	820 (67%)	1396 (67%)
	Single	80 (33%)	191 (32%)	408 (33%)	679 (33%)
	Total	**242 (100%)**	**605 (100%)**	**1228 (100%)**	**2075 (100%)**
Education attained	University	119 (49%)	304 (50%)	483 (39%)	906 (44%)
	Other	123 (51%)	301 (50%)	745 (61%)	1169 (56%)
	Total	**242 (100%)**	**605 (100%)**	**1228 (100%)**	**2075 (100%)**
Employment status	Employed	143 (59%)	450 (74%)	835 (68%)	1428 (69%)
	Other	99 (41%)	155 (26%)	393 (32%)	648 (31%)
	Total	**242 (100%)**	**605 (100%)**	**1228 (100%)**	**2075 (100%)**
Income support	None	165 (68%)	451 (75%)	800 (65%)	1416 (68%)
	Support	77 (32%)	154 (25%)	428 (35%)	659 (32%)
	Total	**242 (100%)**	**605 (100%)**	**1228 (100%)**	**2075 (100%)**

Table 2: Respondent mental health outcome by disruption category.

Outcome	Overall cohort	Disruption group		
		Non-disrupted	Indirectly	Directly
Still distressed	478/2050 (23%)	20/242 (8%)	58/597 (10%)	400/1211 (33%)
Probable PTSD	327/2044 (16%)	5/232 (2%)	40/599 (7%)	282/1213 (23%)
Depression	326/2026 (16%)	13/235 (6%)	57/590 (10%)	256/1201 (21%)
Probable anxiety	335/2021 (17%)	9/232 (4%)	62/590 (11%)	264/1199 (22%)
Suicidal Ideation	156/2056 (8%)	8/240 (3%)	23/601 (4%)	125/1215 (10%)
Total*	**2075**	**242**	**605**	**1228**

* Totals differ from the overall sample size due to missing responses for outcome and exposure reporting

Table 3: Crude and adjusted odds ratios (OR) for mental health problems by disruption category.

Outcome	Disruption group	*n*	Crude OR	Crude *p*-value	*n*	Adjusted OR#	Adjusted *p*-value#
Still distressed	Non-disrupted	260	1†	-	242	1†	-
	Indirectly	654	1.21 (0.72–2.05)	<0.001	597	0.95 (0.47–1.89)	0.878
	Directly	1374	5.77 (3.6–9.23)	<0.001	1211	3.31 (1.79–6.12)	<0.001
Probable PTSD	Non-disrupted	246	1†	-	232	1†	-
	Indirectly	646	3.52 (1.38–8.99)	0.008	599	3.52 (1.36–9.15)	0.01
	Directly	1341	14.43 (5.9–35.31)	<0.001	1213	13.48 (5.45–33.35)	<0.001
Probable depression	Non-disrupted	249	1†	-	235	1†	-
	Indirectly	639	1.88 (1.01–3.49)	0.045	590	1.9 (1–3.62)	0.05
	Directly	1331	4.99 (2.81–8.86)	<0.001	1201	4.26 (2.35–7.73)	<0.001
Probable anxiety	Non-disrupted	247	1†	-	232	1†	-
	Indirectly	639	2.56 (1.33–4.92)	0.005	590	1.55 (0.7–3.44)	0.279
	Directly	1325	6.09 (3.28–11.3)	<0.001	1199	3.64 (1.74–7.62)	0.001
Suicidal ideation	Not Disrupted	256	1†	-	240	1†	-
	Indirectly	648	1.24 (0.55–2.8)	0.597	601	1.02 (0.44–2.35)	0.961
	Directly	1340	3.47 (1.68–7.18)	0.001	1215	2.86 (1.36–5.99)	0.005

Adjusted for age, gender, Indigenous status, receiving income support, education and relationship status
† Reference group

showed a significant association between direct disruption and probable PTSD. By comparison, significant association has also been demonstrated between indirect disruption and probable PTSD, although the strength of association is comparatively weaker. This apparent dose-response relationship offers evidence for the causative relationship between the level of disruption due to flooding and the outcome of probable PTSD.

Direct disruption also demonstrated significant associations with the other four mental health outcomes when compared with non-disruption, namely: still distressed, probable depression, probable anxiety and suicidal ideation. By contrast, no significant associations were found between indirect disruption and these four mental health outcomes.

This is one of the few studies that has sought to investigate the associations between mental health and indirect disruption due to a flooding event. Consistent with previous research, indirect disruption was found to be significantly associated with an increased risk of probable PTSD in comparison with individuals classified as non-disrupted (Waite *et al.* 2017, Paranjothy *et al.* 2011).

To date, there has been little discussion in the literature about mechanisms that might account for this increased risk of probable PTSD in cases where there has been disruption experienced, albeit with no direct damage to people's homes or businesses. Some indications of possible mechanisms might be derived from research on the impact of near-miss experiences and PTSD diagnostic criteria.

Recent literature on 'near-miss experiences' following traumatic events suggests that people who have had near-miss events tend to experience more intrusive thoughts about what might have been and are more likely to think about the actual misfortune of others, which may reinforce intrusions and raise the likelihood of post-traumatic stress symptoms (Poulin & Silver 2019). It might be inferred that those who experienced indirect disruption had a 'near-miss experience' and may have been more sensitive to what might have been and therefore more prone to post-traumatic stress than those who were classified as non-disrupted.

Except for probable depression, these results demonstrate a strong association between losing access to health and social care and every mental health outcome investigated. A similar association was reported by Waite and colleagues (2017), although their results were not mutually adjusted for other disruption types. Interruption to household utilities was also shown to significantly increase the odds of having probable PTSD, consistent with similar findings reported related to the loss of electricity after a flooding event in Hat Yai, Thailand (Assanangkornchai, Tangboonngam & Edwards 2004).

Table 4: Multivariate logistic regression models for mental health outcomes and individual indirect disruption types.

Mental health outcome	Contributing variable	Adjusted odds ratio (95% CI)	*P*-value
Still distressed	**Loss of access to social or health care**		
	No loss of access	1	-
	Loss of access**	1.86 (1.38–2.49)	<0.001
	Loss of utilities		
	No loss of access	1	-
	Loss of access	1.34 (1.02–1.75)	0.034
	Loss of access to internet		
	No loss of internet	1	-
	Loss of internet	1.4 (1.08–1.82)	0.012
Probable PTSD	**Loss of access to social or health care**		
	No loss of Access	1	-
	Loss of access**	1.93 (1.38–2.7)	<0.001
	Loss of utilities		
	No loss of utilities	1	-
	Loss of utilities**	1.9 (1.41–2.56)	<0.001
	Difficulty accessing food		
	No difficulty	1	-
	Difficulty	1.31 (0.94–1.83)	0.105
Probable depression	**Loss of access to social or health care**		
	No loss of access	1	-
	Loss of access	1.51 (1.44–2.82)	0.016
	Loss of utilities		
	No loss of utilities	1	-
	Loss of utilities	1.38 (1.02–1.85)	0.035
Probable anxiety^	**Loss of access to social or health care**		
	Not employed/No loss of access	1	-
	Not employed/Loss of access**	2.67 (1.64–4.35)	<0.001
	Employed/No loss of access	1	-
	Employed/Loss of access	1.05 (0.67–1.64)	0.838
	Loss of utilities		
	No loss of access	1	-
	Loss of access	1.31 (0.98–1.74)	0.07
Suicide ideation	**Loss of access to social or health care**		
	No loss of access	1	-
	Loss of access*	1.74 (1.14–2.66)	0.01
	Loss of utilities		
	No loss of access	1	-
	Loss of access	1.43 (0.96–2.13)	0.079

Each model is adjusted for age, gender, Indigenous status, receiving income support, education, relationship status and an experience of direct disruption; remaining covariates retained and presented as per the purposeful selection method

^Denotes significant effect modification identified (α=0 01)

* Denotes *p*-value ≤ 0 01

** Denotes *p*-value ≤ 0 001

People who lost access to health and social care as well as being unemployed, were more likely to have an outcome of probable anxiety than those who were employed. It may be that people experiencing unemployment are more likely to need access to health and social care than people who are employed. It may also be that unemployment as well as a loss of this access may have a cumulative effect on anxiety.

There were increased odds of reporting probable PTSD for participants who were classified as indirectly disrupted and for those who specifically reported either a disruption of access to social and health care or a disruption to utilities. Therefore, it is possible that the association between an experience of indirect disruption and the outcome of probable PTSD is largely explained by losing access to social or health care and/or a disruption to utilities.

Given the predicted intensification of the effects of climate change (Climate Council 2017), there is likely to be an increasing number of people who are disrupted by flooding events. This study offers evidence that after a flooding event those in need of mental health support will include people who have been directly disrupted and also those who have lost access to social and health care as well as those who have experienced a disruption to utilities provision.

Treatment of mental health problems, including PTSD, following disasters requires specific training for those working in the mental health field (Foa, Gillihan & Bryant 2013). Furthermore, it is recognised that different approaches delivered by professionals may be needed at different stages post disaster (Forbes, O'Donnell & Bryant 2017). Given the findings of this study, it may be prudent to provide the health care workforce with access to appropriate-level training (e.g. mental health first-aid for the general health and community sector, PTSD training for specialists) in preparation for future acute events. Part of this training could involve how to identify people most in need of mental health care, including those who have been indirectly disrupted. Also, given that those who require mental health support after a flood event may need assistance more than six months after a flooding event (Zhong *et al.* 2018), planning is needed to provide support in the longer, not just immediate, term.

Limitations

The self-selection recruitment method means the respondent population is not representative of the population of the flood-affected communities of northern New South Wales. In this study, men, those with less education and those under 25 years of age were under-represented, which is consistent with previous post-disaster postal survey respondent characteristics (Grievink *et al.* 2006). However, this study did not aim to establish prevalence of mental health outcomes after flooding, but rather to examine the relationships between levels and types of disruption and mental health status. Further, to ascertain the relationships of interest, a study's population does not necessarily have to be representative of the general population from which it was derived (Willett *et al.* 2007, Banks *et al.* 2008).

Conclusions

The responses to the community survey conducted in northern New South Wales have contributed to knowledge around mental health effects after a significant flooding event (Matthews *et al.* 2019). The findings are consistent with, and extend, what has been presented in recent literature. It is proposed that people experiencing disruptions to social and health care services or utilities after a flood might be targeted for mental health support.

Further research in this area might investigate causal mechanisms behind indirect disruptions and their associated mental health outcomes. Also, planned follow-up surveys involving respondents who have indicated an interest in future participation may shed light on the longer-term mental health consequences of flooding events.

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Appendix i. Number and proportions of respondents reporting mental health outcomes for each indirect disruption type.

		Loss of access to food		Loss of access to social/health care		Isolated due to flooding		Couldn't get to education		Disrupted utilities		Loss of access to internet		Couldn't get to work	
		Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)	Yes (%)	No (%)
Still	Yes	132 (30)	354 (21)	135 (41)	351 (19)	328 (27)	100 (15)	94 (30)	334 (22)	244 (34)	184 (16)	188 (32)	240 (19)	191 (24)	237 (22)
distressed	No	302 (70)	1363 (79)	197 (59)	1468 (81)	870 (73)	560 (85)	217 (70)	1213 (78)	476 (66)	954 (84)	407 (68)	1023 (81)	612 (76)	818 (78)
	Total	**434 (100)**	**1717 (100)**	**332 (100)**	**1819 (100)**	**1198 (100)**	**660 (100)**	**311 (100)**	**1547 (100)**	**720 (100)**	**1138 (100)**	**595 (100)**	**1263 (100)**	**803 (100)**	**1055 (100)**
Probable	Yes	107 (25)	225 (13)	115 (35)	217 (12)	231 (19)	62 (9)	70 (22)	223 (14)	189 (26)	104 (9)	130 (22)	163 (13)	128 (16)	165 (16)
PTSD	No	324 (75)	1458 (87)	217 (65)	1565 (88)	971 (81)	591 (91)	242 (78)	1320 (86)	536 (74)	1026 (91)	461 (78)	1101 (87)	674 (84)	888 (84)
	Total	431 (100)	1683 (100)	332 (100)	1782 (100)	1202 (100)	653 (100)	312 (100)	1543 (100)	725 (100)	1130 (100)	591 (100)	1264 (100)	802 (100)	1053 (100)
Probable	Yes	97 (23)	237 (14)	95 (29)	239 (14)	204 (17)	82 (13)	65 (21)	221 (14)	158 (22)	128 (11)	109 (19)	177 (14)	105 (13)	181 (17)
depression	No	328 (77)	1435 (86)	233 (71)	1530 (86)	982 (83)	569 (87)	243 (79)	1308 (86)	562 (78)	989 (89)	477 (81)	1074 (86)	685 (87)	866 (83)
	Total	425 (100)	1672 (100)	328 (100)	1769 (100)	1186 (100)	651 (100)	308 (100)	1529 (100)	720 (100)	1117 (100)	586 (100)	1251 (100)	790 (100)	1047 (100)
Probable	Yes	104 (24)	238 (14)	102 (31)	240 (14)	219 (18)	81 (13)	75 (24)	225 (15)	164 (23)	136 (12)	115 (20)	185 (15)	123 (16)	177 (17)
anxiety	No	321 (76)	1432 (86)	225 (69)	1528 (86)	966 (82)	566 (87)	234 (76)	1298 (85)	551 (77)	981 (88)	471 (80)	1061 (85)	670 (84)	862 (83)
	Total	425 (100)	1670 (100)	327 (100)	1768 (100)	1185 (100)	647 (100)	309 (100)	1523 (100)	715 (100)	1117 (100)	586 (100)	1246 (100)	793 (100)	1039 (100)
Suicidal	Yes	52 (12)	106 (6)	50 (15)	108 (6)	105 (9)	32 (5)	37 (12)	100 (6)	79 (11)	58 (5)	50 (8)	87 (7)	61 (8)	76 (7)
ideation	No	377 (88)	1595 (94)	281 (85)	1691 (94)	1092 (91)	635 (95)	276 (88)	1451 (94)	645 (89)	1082 (95)	546 (92)	1181 (93)	745 (92)	982 (93)
	Total	429 (100)	1701 (100)	331 (100)	1799 (100)	1197 (100)	667 (100)	313 (100)	1551 (100)	724 (100)	1140 (100)	596 (100)	1268 (100)	806 (100)	1058 (100)
All		**434**	**1717**	**332**	**1819**	**1210**	**671**	**314**	**1567**	**730**	**1151**	**601**	**1280**	**811**	**1070**

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Rationale and methods for a cross-sectional study of mental health and wellbeing following river flooding in rural Australia, using a community-academic partnership approach

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Abstract

Background: Climate change is associated with greater frequency, duration, intensity and unpredictability of certain weather related events, including floods. Floods harm mental health. There is limited understanding of the mental health and well being effects from river flooding, particularly over the longer term and in rural contexts. This paper describes the rationale, aims, objectives, study design and socio demographic characteristics of the sample for a study measuring associations between flood experience and mental health and wellbeing of residents (particularly those most likely to be negatively impacted and hard to reach) in rural NSW Australia 6 months following a devastating flood in 2017. To our knowledge, the study is the first of its kind within Australia in a rural community and is an important initiative given the likelihood of an increasing frequency of severe flooding in Australia given climate change.

Methods: A conceptual framework (*The Flood Impact Framework*) drawing on social ecological approaches was developed by the research team. It was based on the literature and feedback from the community. The Framework describes putative relationships between flood exposure and mental health and wellbeing outcomes. Within a community academic partnership approach, a cross sectional survey was then undertaken to quantify and further explore these relationships.

Results: The cross sectional survey was conducted online (including on mobile phone) and on paper between September and November 2017 and recruited 2530 respondents. Of those, 2180 provided complete demographic data, among whom 69% were women, 91% were aged 25–74, 4% identified as Aboriginal and/or Torres Strait Islander, 9% were farmers and 33% were business owners.

Conclusions: The study recruited a wide range of respondents and the partnership facilitated the community's engagement with the design and implementation of the study. The study will provide a basis for a follow up study, that will aim to improve the understanding of mental health and wellbeing effects over the longer term. It will provide an important and original contribution to understanding river flooding and mental health in rural Australia, a topic that will grow in importance in the context of human induced climate change, and identify critical opportunities to strengthen services, emergency planning and resilience to future flooding.

Keywords: Floods, Disaster management, Mental health, Vulnerable populations, Climate change

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Background

In late March/early April 2017 extreme rainfall from ex-Tropical Cyclone Debbie resulted in river flooding in the Northern Rivers, a rural area on the north coast of New South Wales, Australia with a sub-tropical climate. Almost all of the rain fell within 24 h and flooded many regions of the Northern Rivers inundating the major population towns of Lismore and Murwillumbah, with extensive damage to housing and infrastructure. For many areas it was as severe as the worst flood on record (1974).

In 2015, the economic cost of weather-related and other natural disasters in Australia was estimated to exceed $9 billion with the social cost (e.g. impact on health and wellbeing, education, employment) contributing an equivalent or larger component than physical infrastructure costs [1]. This annual cost is estimated to double by 2030, not counting the potential impacts of climate change [1]. Floods are the most expensive weather-related event experienced in Australia [2].

Analysis of global flood data and associated population impact from 1975 to 2016 showed a significant increase in flood-affected population and mean annual flood-induced mortality in Australia [3]. Based on the output of a number of climate models, an increase in the frequency of floods is likely along the east coast of Australia [4].

There are two broad categories of floods: coastal floods caused by high tides and storm surges; and fluvial (river) flooding caused by heavy rainfall in river catchment areas [5]. River floods are the most common flood disasters globally [3].

Flooding and mental health

The related constructs of mental health and wellbeing (the subjective experience of affect and life satisfaction, psychological functioning and self-realisation [6]) influence individuals' ability to cope with everyday life stresses, relationships with others, working productively, contributing to community and fulfilling one's potential [6, 7]. Although damage from flooding to the built and natural environment and, in some instances, damage to physical health is immediately evident, floods can also harm mental health and wellbeing contemporaneously and subsequently. These harms can be substantial. For example, in the UK, mental health problems have been estimated to account for 80% of all Disability Adjusted Life Years attributable to floods [8]. While the most immediate effects of flooding (injuries, infections, chemical hazards, and disruption to health and social services) are well documented, the mental health and wellbeing effects of river flooding, particularly in rural areas and over time, are less well understood [2, 9].

Study aims and objectives

This study therefore aimed to measure mental health and wellbeing 6 months following the flood in rural NSW, and explore the association between flood exposure and mental health and wellbeing to quantify and better understand the associations in relation to a proposed Flood Impact Framework (Fig. 1), in order to inform current and future disaster support and mental health service provision. The specific objectives of the study were to:

1. describe the extent of the impact of the April 2017 flood on the physical environment of communities in the Northern Rivers' Region
2. explore the associations between mental health and wellbeing and:
   a. the nature and extent of exposure to flooding
   b. perceptions of the adequacy of pre-flood warning systems, plans and mitigation infrastructure and the subsequent disaster relief service response
   c. levels of community and personal resilience
3. conduct subgroup analyses of the association between flooding and mental health and wellbeing of the following key interest groups who are disproportionately vulnerable to the effects of weather-related events: respondents living in disadvantage (indicated by receipt of government income support); business owners; farmers; respondents identifying as Aboriginal and/or Torres Strait Islander; respondents 75 years and older; and the young (16 25 years).

Ethical approval

The study, sub-study and related study were approved by the University of Sydney Human Research Ethics Committee (reference-2017/589) and the Aboriginal Health and Medical Research Council Human Research Ethics Committee (reference-1294/17). Potential respondents were advised that completing the questionnaire would be taken to mean their consent to participate in the study.

Community-academic partnership

A community-academic partnership [10] was integral to the design, development and implementation of the study, in particular to recruiting participants to the study [11]. The partnership developed over time, beginning in late April 2017 just a few weeks after the flood, and is ongoing. It has taken many forms including recruiting new staff from the community into the research team and establishing two Community Advisory Groups (CAGs). Details are expanded below under 'Study Design'. Partnerships between community and researchers have been described as central to addressing the gap between

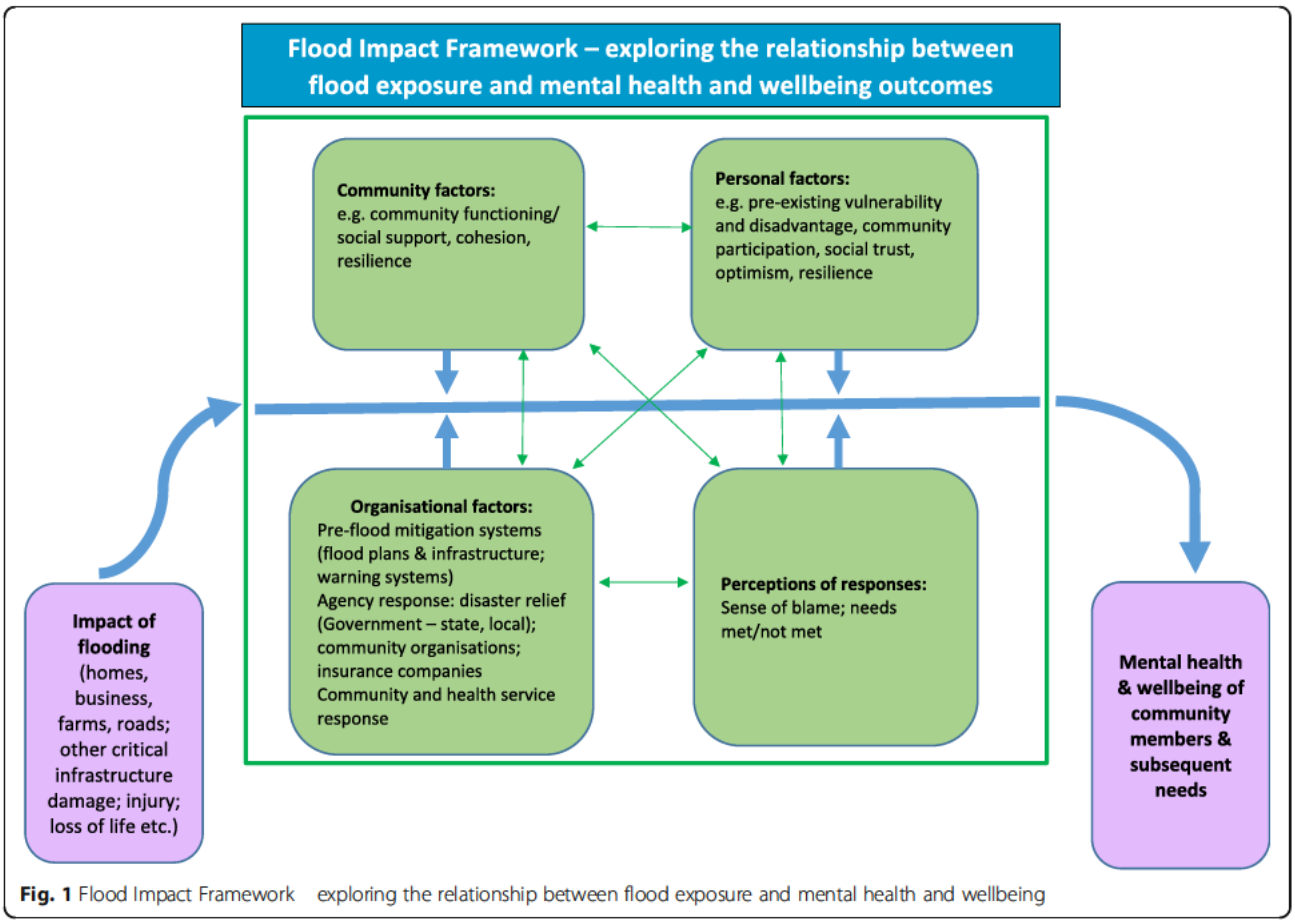

Fig. 1 Flood Impact Framework exploring the relationship between flood exposure and mental health and wellbeing

evidence and practice [11, 12] and the benefits of these partnerships include ensuring the relevance of research questions and designing studies to be of direct use to the community [11].

The flood impact framework

A conceptual framework, the 'Flood Impact Framework' (Fig. 1) was developed by the academic research team and was based on prior empirical research on flood and other natural disasters. We presented the draft Framework to the community (see Fig. 3 – timeline) for discussion, adjustment and eventual agreement based on their expertise and experience. The discussion was primarily around capturing the factors which might contribute to or mitigate the effects of being exposed to a flood and mental health and wellbeing outcomes. Community members advised us in the context of their community membership as well as their work/voluntary roles. The Framework provided a starting point to articulate potential relationships between flood exposure and mental health and wellbeing outcomes (purple boxes), taking into account other contributing factors (green boxes), and helped guide the choice of measures for the questionnaire. The key path of interest in the Framework was between exposure to the flood and mental health and wellbeing outcomes. The factors identified (the four green boxes) act as potential mediators of that path. All factors interact. The utility of the Framework will be reviewed in the light of findings from our research described here including the survey results, and refined accordingly.

Drawing on social ecological models which recognize multi-level influences on health outcomes [13–15], the Flood Impact Framework suggests that a combination of personal, community, organisational factors, a person's response to these factors, and degree of flood impact predict mental health and wellbeing outcomes. These factors can be proximal, intermediate and distal and may interact directly or indirectly [16]. The Framework is focused on the social aspects of social ecological models (although we acknowledge the potential health implications of changes in biophysical/living systems). The Framework reflects assumptions that community, personal, organisational and response factors mediate the impacts of flooding on mental health and wellbeing, and that these mediating factors may directly influence the impact of each other; for instance, a belated agency response in a flooded area may directly affect the community's capacity to provide support for one another,

which in turn may affect individuals' trust and optimism, and whether their needs were met or not met by agencies and their community.

A prior example of the use of a social ecological framework to promote recovery after a natural disaster is provided by The Joint Centre for Disaster Research following the 2010–11 New Zealand earthquakes [17]. Paralleling the Flood Impact Framework, these authors identified individual, community, and societal/agency factors as key contributors to resilience/adaptive capacity. What the Flood Impact Framework adds to the New Zealand framework is a specific focus on the direct and indirect impacts of flooding, and whether or not individual needs are met by community, organisational and personal resources.

Although the Flood Impact Framework was developed prior to the publication of a recent systematic mapping study of the long-term physical and psychological health impacts of flooding [18], the factors in the Framework closely match the factors outlined in this mapping study. What the present Framework adds to the systematic mapping study [18] is hypothesis-generating capacity by positing putative links between different factors in the framework. Similarly, the Flood Impact Framework reflects a number of the factors impacting on mental health identified in a recently published UK study of wellbeing after floods (e.g. dislocation from home, community factors, public policy, emergency responses, perception of responses, etc.) [19].

The key elements of the Framework (impact of flooding; community, personal and organisational factors, and perceptions of organisational responses) are outlined below and have previously been associated with negative mental health and wellbeing outcomes following extreme weather-related events.

Impact of flooding

The direct and indirect impact of flooding, such as house inundation [20–22], displacement [23], businesses flooded [24] and/or disrupted access to services [21, 25] have been associated with elevated negative mental health outcomes compared to unexposed groups.

Community factors

Community cohesion [26–29], resilience [2, 30, 31] and participation [26, 27, 32] in the form of informal social connectedness (such as having contact with friends, family and neighbours) [18, 27, 33], and civic engagement (such as participating in organised community activities) [2, 32] appear to play an important role, influencing the link between extreme weather-related events and mental health outcomes. Community cohesion may often mitigate negative mental health impacts, but in some cases community divisions or inappropriate volunteer support can heighten negative impacts [19].

Personal factors

Personal factors such as pre-existing vulnerability and disadvantage [21, 30, 34], previous flood experience [9], and personal resilience [35] similarly contribute to the combination of factors which predict mental health and wellbeing outcomes. For instance, people who are socio-economically disadvantaged are more likely to live in flood-prone areas [36] and tend to have fewer resources to recover from its impacts [21, 34]. Those living in rural and remote areas [37] and older adults [38] are also more vulnerable to the effects of flooding.

Organisational factors

Finally, organisational factors contribute; for example, pre-flood mitigation systems, and warning systems [2], the response of Federal, State and local governments, community organisations and insurance companies [39, 40] all affect the mental health impact of experiencing a flood. In particular, lack of support from insurance companies has been extensively implicated in ongoing mental health problems [39, 41, 42]. The immediate and ongoing response of health and community services to weather-related events has been shown to be an important contributing factor to mental health and wellbeing and to recovery following severe weather-related events [43, 44]. In the English flood study described previously, perceived lack of evacuation warning was associated with greater depression and post-traumatic stress disorder (PTSD) [23].

Perceptions of organisational responses including blame

The community raised a number of issues around warning about the flood including that it was: not received by some, too late for some, too early for some (particularly business owners), inaccessible for some, gave inconsistent information, and/or was not sufficiently detailed. This was discussed with the community including at CAG meetings. As highlighted in other research [19], the Framework therefore also included perceptions of organisational responses, including blame [9] (to explore whether blame for perceived failures in Government's or agencies' responses might contribute to mental health outcomes [40, 45]).

This paper describes the rationale, aims, objectives, study design and socio-demographic characteristics of the sample for a study measuring associations between flood experience and mental health and wellbeing of residents in rural NSW Australia 6 months following devastating flooding in 2017. The results of the study (the cross-sectional survey) and the related study (flood mapping study) will be published separately to this paper.

Methods

Study location

Six Local Government Areas (LGAs) within the Northern Rivers region were included: Ballina Shire, Tweed Shire, Richmond Valley, Kyogle, Byron Shire and Lismore City (Fig. 2). The total estimated residential population of these LGAs was 239,604 in 2016 [46]. From the Australian Bureau of Statistics (ABS) 2016 census estimates (5 year age groups), 82% of this population was 15 and over [47]. The region has higher proportions of older people and Aboriginal people compared to state averages and has experienced recent high population growth driven by coastal migration and counter-urbanisation. The region includes many areas of socio-economic disadvantage (in 2016 27% of the population was living in the lowest quintile of socio-economic disadvantage, with a range of 6–58% across different locations) [48]. The region is a known hotspot for weather-related extreme events, particularly flooding [36].

Study design

The whole study was underpinned by a community-academic partnership approach and consisted of a Main study (which collected data using a cross-sectional survey) with one sub-study (measuring the participation rate and respondent/non-respondent bias in the Main study) and one related study (a flood mapping study). Fig. 3 shows a timeline of how these elements of the study fitted together.

Main study

The Main study was a cross-sectional survey. The survey was made available online, on mobile phone and in paper form between September and November 2017.

Recruitment methodology

The aim of recruitment was to reach people living in the Northern Rivers region at the time of the 2017 flood who experienced damage to any of five physical locations or

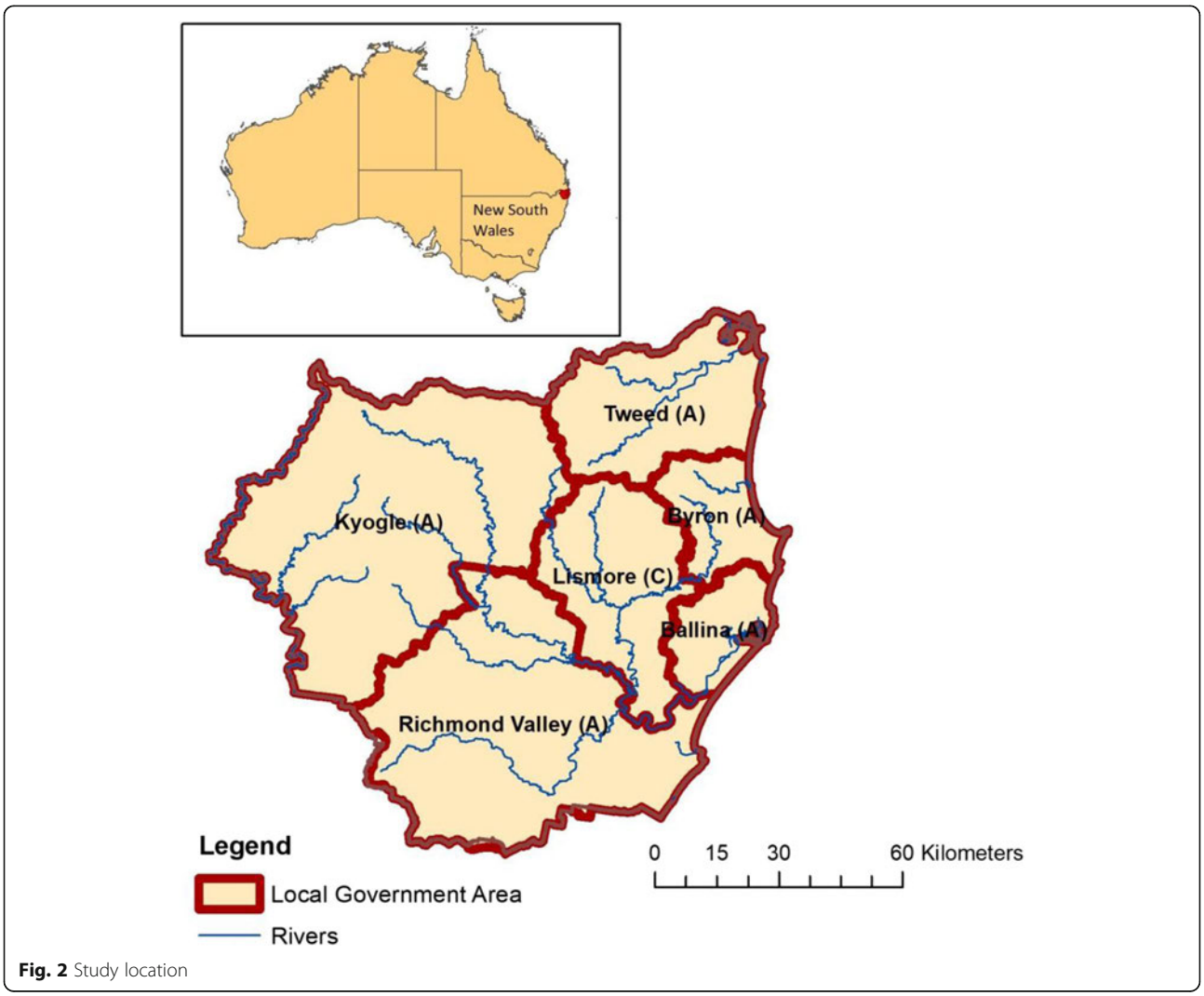

Fig. 2 Study location

30 March-1 April 2017	April 2017	May 2017	June 2017	July 2017	August 2017	September 2017	October 2017	November 2017	Dec 2017-ongoing
Flood event – Northern Rivers Region NSW, Australia									
	Meetings of **Research Team** (many of whom were residents of Northern Rivers Region and therefore part of the community themselves)								
	Establishment of a **Community Academic Partnership** and maintenance of this approach								
	Meetings with **community** via local networks to discuss the potential for useful research, agree on research questions and study design. Many of these community members were part of the Community Advisory Groups								
			Community Advisory Groups meetings. Advice around: research priorities, key research question/s, study design	**Community Advisory Groups** meetings. Advice around: study aims and objectives, Flood Impact Framework checked, content of survey tool	**Community Advisory Groups** meetings. Advice around: piloting survey tool, recruitment strategy to maximise participation	**Community Advisory Groups** meetings. Advice around: maximising participation in the survey (including survey launch events)	**Community Advisory Groups** meetings. Advice around: strategies to reach target population groups	Community Advisory Groups met every few months after this Oct 2017 meeting	
		Recruitment to and work of the **Community Engagement Team** (part of the Research Team)							
	Development of the Flood Impact Framework by the Research Team from the literature and checked with the community via Community Advisory Groups and other community members								
			Preparation for and submission to **ethics** committees						
					Piloting survey tool for **Main study (cross-sectional survey)**				
						Main study (cross-sectional survey) data collection for 6 weeks online and on paper			
						Recruitment and training of the **Sub-study** (participation rate and respondent/non-respondent bias study) recruitment team			
								Sub-study (participation rate and respondent/non-respondent bias study) during the final 2.5 weeks of data collection	
				Related Study (the Flood Mapping study). Analysis of data to assess difference in vulnerability of those inundated and those not. Provision of comparison data for survey respondents and the wider Northern Rivers Region population.					
									Data analyses, dissemination, and refinement of the Flood Impact Framework

Fig. 3 Timeline Main study, sub study and related study of mental health and wellbeing following river flooding

structures: suburb; non-liveable areas of their home (e.g., garden shed, garage); liveable areas of their home (e.g., bedrooms); income-producing property (business/farm, if applicable); and the home of a significant other, as well as those who were not exposed (no surrounding infrastructure damage, evacuation or displacement). As some of the key interest groups are difficult to reach (e.g., people living with disadvantage), purposive sampling utilising a snowball technique recruiting respondents via personal and local organisational networks and encouraging respondents to raise awareness of the survey with friends, family and colleagues was conducted. As the study did not aim to assess population prevalence of flood exposure or mental health outcomes but rather to quantify relationships between flood impact and mental health risk the sample was not randomly selected, but was purposively recruited [49]; the focus was to ensure adequate numbers of respondents from key interest groups to enable analysis of exposure and outcome for these groups.

Community-academic partnership was key to the study design and implementation, particularly in facilitating recruitment to the Main study and in providing support for respondents completing the questionnaire. The partnership with community took many forms including recruiting two new staff members from the community into the research team with a focused community engagement role; one with an impressive track record in local TV/radio and print media journalism and the other, one of three women who were the driving force behind the establishment of an inspiring self-organising group (*Helping Hands*) connecting hundreds of volunteers with locals requiring support following the flood. The leader of, and the five members of the recruitment team for the Sub-study (see *Sub-study* section below and Fig. 3) were also highly networked, experienced, and well known members of the community.

Two Community Advisory Groups (CAGs) were also established one in Lismore and one in Murwillumbah. The CAGs included representation from around 60 local health and community organisations, business groups and state and local government authorities, met frequently and provided critical advice on the research questions, study design, recruitment strategies, questionnaire content (including piloting), analysis priorities and dissemination strategies.

The community-academic partnership was initiated by academic researchers. Members of the partnership were not funded to participate in the partnership, their commitment to contribute (either in one-to-one meetings by phone or face to face, or by being a member of one of the CAGs and attending CAG meetings) stemmed from a commitment to the community, grounded in the shared experience of the flood. The partnership was large in comparison to other studies [10] and was made up of NGOs, community organisations, local government, service providers, members of the public, the business community and others, many of whom were members of the CAGs. The CAGs had agreed Terms of Reference which helped to clarify purpose and roles. The nature of the community-academic partnership was characterised by a goal (to successfully complete the research and disseminate the findings so that they could be used to inform improved support for the community before, during and after flooding), relevant to the community, and involved community members as well as academics. As such the community-academic partnership was congruent with the conceptual definition of community-academic partnerships by Drahota et al. [10] Description of the timeline for the partnership is provided in Fig. 3.

Initial invitation to participate in the survey (most commonly by email) was via social and organisational networks of community organisations, the CAGs, the local health service, local government authorities and business/farming groups. For example, the local health service (one of the largest employers in the region) who were part of the CAGs sent an email to their all-staff list inviting participation and including a link to the questionnaire online and instructions about how to access a paper version of the questionnaire if preferred. This approach was supplemented by an extensive local media (print and broadcast) advertising campaign, fliers and posters (which included a QR code - a 2-dimensional bar code that enabled potential respondents to access the survey website easily using their mobile phones). The posters and leaflets along with paper surveys (with franked return envelopes) were placed in central community locations such as council offices, coffee shops, in every library and post office, and in shops belonging to charitable organisations such as Lifeline, Interrelate, St Vincent de Paul and the Salvation Army. Social media was also used intensively and strategically to raise awareness and invite potential respondents, including Twitter and a Facebook page incorporating short videos of key community members talking about the survey. The survey was launched at face-to-face media and community events marking 6 months since the flood. The team's community engagement staff had high visibility in the community throughout the duration of the survey period by staffing a stall at farmers' markets and attending a plethora of other community events. Appropriately skilled members of relevant organisations (e.g. Lifeline, a crisis support service) received information about the ethical aspects of conducting the survey and provided one-to-one support for survey completion. Door-to-door recruitment took place in Lismore and Murwillumbah.

When participation in the Main study was reviewed with the community via the CAGs at the halfway point a

number of specific strategies were discussed, agreed and employed to maximise participation from men (promoting the survey via men-specific organisations such as the Men's Shed, posting videos on the project's Facebook page of men talking about completing the questionnaire), older people (taking paper copies of the questionnaire and advertising material to residential aged care facilities) and people aged 16–25 years (promoting through networks of youth workers and Facebook). A leaflet delivered by post to residents in Lismore and Murwillumbah was also added at this point.

A lottery style draw of gift vouchers for $100 to spend in local businesses was offered to respondents who opted to put their details into the draw.

Questionnaire development

A draft questionnaire based on the conceptual Flood Impact Framework was developed by a leading expert in extreme weather-related events and their impacts on population mental health, the scientific team and in partnership with the community. Where possible, pre-existing validated measures and survey tools from previous flood research [22, 25, 34] (to facilitate comparison) were used. Where necessary, new measures were developed. The CAGs facilitated piloting the penultimate version of the questionnaire (which was then revised into the final version) by recruiting from their networks 30 volunteers from various socio-demographic backgrounds.

Questionnaire content

The final 58-item questionnaire covered: socio-demographic characteristics; the six flood exposures established a priori (suburb, non-liveable areas of their home, liveable areas of their home, business/farm and/or the home of a significant other flooded, plus not exposed to any of these evacuated or displaced); respondents' experiences during the flood including evacuation and displacement; mental health items and items measuring individual and community resilience and social capital. Table 1 contains information on the main measures and their origins and how they relate to the Flood Impact Framework. In addition to these items, the questionnaire contained eight free-text opportunities inviting respondents to report their perspectives on their flood experience.

As the questionnaire was rather long, respondents were offered the choice between completing a shorter (15 min) or longer (25 min) version. The shorter version (the first part) contained socio-demographic variables, flood experience items, mental health measures and a post-traumatic growth measure. The longer version included all of the above as well as personal and community resilience measures.

Consistent with previous research, a high level of community distress following the flood was anticipated [2, 38, 63]. Caring for respondents and minimising the risk of harm to their mental health was, therefore, a core component of the questionnaire design. For example, the number of difficult items was minimised, more difficult items (e.g., items about suicide) were located after or before less difficult items, free-text opportunities were included, any distress caused by completing the questionnaire was acknowledged and apologised for in the introductory material, and contact information for counselling and support services featured prominently throughout.

At the end of the survey (short and full versions) respondents were asked if they would be willing to be contacted in future to participate in further research about the flood. The online survey was generated using Qualtrics software (version Sept-Nov 2017, Qualtrics Provo Utah).

Planned data analyses

The dataset for the Main study has been cleaned and an initial descriptive analysis including means and standard deviations, frequencies and proportions for all social and mental health and wellbeing variables undertaken (Matthews V, Longman JM, Berry HL, Passey ME, Bennett-Levy J, Morgan G, et al.: Mental health six months after extensive flooding from cyclone Debbie in rural Australia: a cross-sectional analysis through an equity lens, submitted). These statistics will be calculated separately for the sample as a whole, for the six exposure groups and the key interest groups. Mental health and wellbeing outcomes across each of the exposure and key interest groups will be examined. Respondents reporting none of the exposures will form a control group for comparison to groups which reported one or more exposures. Analysis of proposed protective factors for mental health and wellbeing (such as community resilience) between the different flood-exposure groups will be undertaken. A broad range of inferential statistical procedures will be employed to describe relationships between exposure and outcome variables and associations with other factors according to the proposed Flood Impact Framework. These may include calculation of correlation coefficients, analyses of variance, hierarchical and logistic regression analyses, cluster analyses and multi-level and structural modelling. The necessary data have been collected to adjust for a wide variety of factors known to predict psychiatric morbidity. Analyses will assist in evaluating the plausibility of the proposed Flood Impact Framework and in improving both the Framework and future study design.

Free text data will be analysed deductively using a content analysis approach following Elo et al. [64]

Sub-study - The participation rate and respondent/non-respondent bias sub-study

A randomised stratified cluster sample sub-study was conducted to examine participation rate and respondent/

Table 1 Main questionnaire items, their origins and how they relate to the Flood Impact Framework (Fig. 1)

Item	Origin (*and scoring where relevant*)	Relationship to Flood Impact Framework
Socio demographics variables: • Age • Gender • Indigenous status • Relationship status • Education level • Employment status • In receipt of income support • Farmer • Business owner	N/A	Personal characteristics, including those identifying key interest groups
Flood exposure (liveable area of home flooded; business flooded; non liveable area of home flooded e.g. garage; suburb flooded; home of close friend or relative flooded; none of the above). Degree of flooding: water above your head height through entire home/property; water between knee and head height (more than 50 cm) through entire home/property; water below knee height (about 1 50 cm) through entire home/property; water in some but not all areas of home/property	Derived from the Brief Weather Disaster Trauma Exposure and Impact Screen [9] and the English National Cohort Study on Flooding & Health [22].	Impact of flooding
Evacuation: • Did you have to evacuate your home/business? • How much warning did you get?	Derived from the English National Cohort Study on Flooding & Health [22].	Impact of flooding Pre flood mitigation systems: Warning systems
Displacement: • Because of the flood did you have to live elsewhere?	Derived from the Brief Weather Disaster Trauma Exposure and Impact Screen [9] English National Cohort Study on Flooding & Health [22].	Impact of flooding
Support at the time of the flood: • Did support requested from Govt/Community organisations/insurance/emergency services/ volunteers meet your needs?	Bespoke measure developed for the Flood Impact Framework	Agency response: disaster relief Perceptions of responses Community & health service response: mental health & wellbeing needs
Blame: • Are Govt/Community organisations/insurance/ emergency services/volunteers to blame for distress?	Bespoke measure developed for the Flood Impact Framework	Perceptions of responses: sense of blame
Previous flood experience: • Have you ever been in heavy rain or floods in which your home, business, workplace or school was damaged?	Bespoke measure developed for the Flood Impact Framework	Previous flood exposure, cumulative flood exposure
Post traumatic growth: • Have the severe rain and flood resulted in you being able to make any positive changes in your life?	Bespoke measure developed for the Flood Impact Framework	Personal factors
Individual and community resilience: • Personal social capital community participation	Australian Community Participation Questionnaire [50]. *Seven point agree/disagree scale*	Community factors Personal factors
• Community functioning	A measure of 'social' (or 'generalised') trust from Berry et al. 2003 [51], a question from the CRACE study [52] and a bespoke measure for the Flood Impact Framework	Community factors
• Personal social cohesion connection, sense of belonging & support	Two sub scales from the Interpersonal Support Evaluation List (Cohen et al. 1985 [53]) Berry 2008 [54] *Seven point agree/disagree scale*	Community factors Personal factors
• Social trust	Adapted by Berry, 2008 [55] from the Organisational Trust Inventory (OTI) (Cummings & Bromiley,1996 [56]) and the World Values Survey (Inglehart et al., 2000 [57]) *Seven point agree/disagree scale.*	Personal factors

Table 1 Main questionnaire items, their origins and how they relate to the Flood Impact Framework (Fig. 1) *(Continued)*

Item	Origin (*and scoring where relevant*)	Relationship to Flood Impact Framework
• Generalised reciprocity	Adapted by Berry, 2008 [55] from the World Values Survey (Inglehart et al., 2000 [57]) *Seven point agree/ disagree scale*	Personal factors
• Trait optimism	Adapted from the Life Orientation Test Revised (LOT R) (Scheirer et al. 1994) [58] *Seven point agree/disagree scale*	Personal factors
Mental health and wellbeing outcome measures: • Flood specific Still distressed about the flood	Brief Weather Disaster Trauma Exposure and Impact Screen [9] *"Are you still currently distressed about what happened during the flood?" Yes/No*	Mental health & wellbeing of community members and subsequent needs
• Flood specific Post Traumatic Stress Disorder (about the flood)	Post Traumatic Stress Disorder Checklist (PCL 6) [59]. A list of complaints that people sometimes express after extreme rain and flooding. *Cut point for probable diagnosis was ≥ 14* [59]	Mental health & wellbeing of community members and subsequent needs
• Not flood specific Depression	Patient Health Questionnaire (PHQ 2) [60]. *Cut point for probable diagnosis was ≥ 3* [60]	Mental health & wellbeing of community members and subsequent needs
• Not flood specific Anxiety	Generalised Anxiety Disorder scale (GAD 2) [61]. *Cut point for probable diagnosis was ≥ 3* [61]	Mental health & wellbeing of community members and subsequent needs
• Not flood specific Suicidal ideation	A single suicidal ideation item from the Screening Tool for Assessing Risk of Suicide [62] *Yes/No*	Mental health & wellbeing of community members and subsequent needs

non-respondent bias within the Main study sample in the flooded areas of the two major population centres impacted by the flooding (Lismore and Murwillumbah). The sub-study aimed to: assess participation rates achieved through the recruitment strategies employed in the Main study, and thus provide evidence of the effectiveness of these strategies in the most flooded areas; determine characteristics of people in the sample who specifically declined to participate in the survey, for the purpose of assessing respondent/non-respondent bias; and to maximise recruitment of people in areas most inundated by the floods.

The sub-study involved door-to-door recruitment within clearly defined areas in Lismore and Murwillumbah based on ABS 2016 census mesh blocks (around 100 dwellings per block, and the unit of random selection), stratified by land use pattern (residential, primary production or commercial) and exposure classification (from local council maps indicating that the land was flooded or not flooded). Mesh blocks that were flooded were weighted such that they had twice the probability of selection. Three attempts to collect data from every household within each selected mesh block were made. Within households, all residents ≥16 years old were eligible for inclusion in the sub-study and invited to participate. The door-to-door recruitment was undertaken by local skilled and trained recruiters who also assisted people in completing the questionnaire on computer tablets or on paper if required. Within each household, data were collected on the number of residents ≥16 years who were living in the study area at the time of the flood, the number of residents responding to the sub-study, and for each of these respondents, their age, gender, whether or not they had heard about the flood survey (Main study), whether they had completed it and whether they were willing to do so now. The sub-study was undertaken during the final two and a half weeks of recruitment for the Main study (see Fig. 3), and took twelve working days.

Related study - the flood mapping study

The aim of this related study was to compare socio-demographic and selected health characteristics of Northern Rivers residents who lived within areas inundated by floodwater from the 2017 flood with those who lived in areas that were not inundated, in order to assess difference in vulnerability between those inundated and not. The study used flood maps (the "flood footprint" i.e. where the flood water was located) provided by the NSW Office of Environment and Heritage together with flood maps from local councils to compare characteristics of residents who lived in the flood footprint with residents of the wider Northern Rivers community. This included:1) describing the population-level

socio-demographic and health characteristics of flood footprint residents by overlaying information from the ABS 2016 Population Census [65] and the large cohort study [66] with flood maps, and comparing the flood footprint residents with the wider Northern Rivers population; and 2) comparing the socio-demographic characteristics of the survey respondents with the Northern Rivers population. Findings from this study are currently being prepared for publication and will be disseminated extensively as part of the community-academic partnership.

Results

Over 2500 people participated in the survey, with three-quarters participating online and the vast majority (89%) completing both sections of the questionnaire. Some 2180 (86%) respondents provided full demographic data (Table 2).

Approximately seven out of every ten respondents were women. Only 6 % of respondents were in the youngest age bracket (16–24) compared to the population of the study location (10%). Similarly, it was difficult to recruit older people (75+ years) into the survey who comprised only 3 % of respondents compared to 10% in the wider population. Farmers were over-represented in the sample (9% compared to 5% in the population), as were respondents in receipt of Government income support (31% compared to 18%), and one-third of respondents were business owners. Respondents identifying as Aboriginal and/or Torres Strait Islander Australians constituted 4% of the sample, matching the proportion in the local population. The large majority of respondents reported at least one flood exposure (91%) compared to those who did not (9%).

Compared to other respondents, older respondents were more likely to complete the paper rather than online questionnaire (60% of older respondents) as were those in receipt of income support (37% completed the paper questionnaire rather than online). These respondents were found to reside in the more disadvantaged parts of the region which also suffered the worst of the flooding (Matthews V, Longman JM, Berry HL, Passey ME, Bennett-Levy J, Morgan G, et al.: Mental health six months after extensive flooding from cyclone Debbie in rural Australia: a cross-sectional analysis through an equity lens, submitted), as in other studies [34, 67].

The door-to-door participation rate and respondent/non-respondent bias sub-study was conducted in 17 randomly selected mesh blocks in the two main towns (Lismore and Murwillumbah), ten of which were in the flooded areas. The mesh blocks contained an estimated 1494 individuals in 903 residences. Of these, 1062 individuals and 663 residences were in the flooded areas (73 and 71% respectively). Data were collected from 713 individuals in 399 residences, 48% of the estimated resident population. Rates of awareness of the survey were similar within and outside the flooded areas (48 and 52%). The participation rate (individuals who had completed the survey prior to being door-knocked) was 4.9% from individuals who lived in the flooded areas and 5.0% from those outside these areas. Women were over-represented in the individuals who had already completed the questionnaire (69%). Individuals who had not completed the questionnaire were asked if they were willing to do it. A total of 110 declined (17%), the majority of whom (62%) did not live in the flooded areas, and 537 agreed.

Discussion

Using a cross-sectional survey, in conjunction with a community-academic partnership approach, this study aimed to quantify relationships between river flood exposure and mental health and wellbeing in a rural region of NSW, Australia, focusing on key interest groups (older people, young people, farmers, business owners, Aboriginal and/or Torres Strait Islander people and those living with socio-economic disadvantage); and to further understand these relationships within the context of a proposed Flood Impact Framework. To our knowledge, the study is the first of its kind within Australia in a rural community and is an important initiative given the frequency of severe flooding and the likelihood that this will increase given climate change [2] (for example the latest IPCC report includes that no remaining Arctic sea ice is ten times more likely at 2 °C above pre-industrial temperature levels compared to 1.5 °C, which can lead to intense flooding [68]) and the substantial harms to mental health that flooding can bring [8].

The community-academic partnership led to a design that was oriented towards the priorities of the community and therefore resulted in community engagement with the study design and implementation, and in substantial community investment in the results. This approach offers the potential for research findings to influence on-going policy and service development as well as further research.

The Flood Impact Framework, like other social ecological approaches [13–15, 17], points towards the value of a systems-thinking approach [69]. It does this by incorporating the proposition that the mental health of individuals (in the context of climate change events) is profoundly influenced by a dynamic system of interacting factors. These include organisational and community capacity to respond effectively, social disadvantage (e.g. living in flood-prone areas, lack of access to insurance) and resource allocation. The factors identified are likely also to interact with biophysical/living systems though these are not a focus of the study. Typically, it is those people who are already significantly disadvantaged who are most impacted by

Table 2 demographic characteristics, flood exposure and mode of participation of respondents

			n (%)	
Number and mode of respondents:				
Total respondents			2530 (100)	
Respondents online			1907 (75)	
Respondents on paper			623 (25)	
Respondents completing both parts of questionnaire (1 and 2)			2251 (89)	
Total respondents providing full socio demographic data			*2180 (86)*	
	Online n (within row %)	On paper n (within row %)	*n* (% of 2180)	Population across the 6 local government areas *n* (%)
Total population across 6 local government areas				239,604
Socio demographic characteristics (*n* = 2180)				
Women	1191 (79)	309 (21)	1500 (69)	123,343 (51)
Men	458 (67)	222 (33)	680 (31)	116,261 (49)
Age 16 24	102 (85)	18 (15)	120 (6)	24,367 (10)[a]
Age 25 74	1517 (76)	468 (24)	1985 (91)	149,566 (62)
Age 75+	30 (40)	45 (60)	75 (3)	24,592 (10)
Identified as Aboriginal and/or Torres Strait Islander	58 (75)	19 (25)	77 (4)	9739 (4)
Farmer or farm worker	144 (76)	45 (24)	189 (9)	4581 (5)
Business owner	502 (70)	212 (30)	714 (33)	Not available
Single (vs in a relationship, e.g., married)	497 (71)	207 (29)	704 (32)	73,240 (43)
Has a university degree	807 (84)	150 (16)	957 (44)	27,966 (14)
In paid employment (full or part time)	1237 (82)	274 (18)	1511 (69)	96,421 (49)
In receipt of Government income support	428 (63)	248 (37)	676 (31)	69,389 (18)
Flood exposure groups (*n* = 2180)				
Suburb flooded	1224 (74)	435 (26)	1659 (76)	
Non liveable areas of their home flooded	761 (74)	274 (26)	1035 (48)	
Liveable areas of their home flooded	306 (67)	154 (33)	460 (21)	
Business/farm flooded	268 (73)	97 (27)	365 (17)	
Home of a significant other flooded	1065 (77)	315 (23)	1380 (63)	
Not exposed to any of the above	153 (77)	45 (23)	198 (9)	
Future research (*n* = 2180)				
Willing to participate in further research (yes or possibly)	1219 (88)	163 (12)	1382 (63)	

[a]aged 15 24 available only

weather-related events like floods [9, 70] and have access to the fewest resources in the face of climate change events [67]. Systems-thinking highlights the value of pitching interventions at multiple levels [69] simultaneously, for example at organisational and community levels as well as at individuals.

Study strengths and limitations

There are a number of important methodological complexities associated with undertaking research of this nature. In order to address the key aims and objectives of the study, a non-probability, purposive sample with a snowball approach to recruitment was adopted. This was a pragmatic, appropriate, timely and affordable way to access key interest groups, some of which are known to be hard to engage in research [71]. This approach, while necessary, meant that the sample was not representative of the Northern Rivers population (as illustrated in Table 2) and therefore findings cannot be generalised to that population. Using a random

sampling recruitment technique in a community the size of the Northern Rivers would likely not have resulted in sufficient power to compare between key interest groups e.g. flood affected farmers, or flood affected Aboriginal and/or Torres Strait Islander people. Whilst other studies of the association between flooding and mental health have employed more costly conventional approaches, including random-digit dialling and mailing out to households [22, 34], they have struggled with selecting appropriate sampling frames, low response rates and selection bias [2, 9, 22, 34, 72]. They have found it a challenge to engage difficult-to-reach populations such as people living in disadvantage [22], one of the key interest groups in this study.

The approach to recruitment in this study was successful in achieving the required sample size and in accessing a number of difficult-to-reach populations. It was also successful in raising awareness of the survey with around one half the population in the areas that were door-knocked. Given that the aim of the study was to identify relationships between exposure to the flood and mental health, rather than to assess prevalence (of exposure or outcomes) for the Northern Rivers population, the recruitment strategy focused on reaching potential respondents in the key interest groups rather than on securing a random and representative sample. Further, the door-to-door participation rate and respondent/non-respondent bias sub-study demonstrated that awareness of and participation rates in the survey were similar in the flooded and non-flooded areas targeted by the sub-study (Lismore and Murwillumbah) and participation was higher in these key target areas than in the overall Northern Rivers population.

The cross-sectional design of the study constrains the ability to make causal inferences. However, it supports the preliminary goals of exploring the plausibility of hypothesised associations between variables; testing new measures and concepts; and examining differences in the nature and extent of exposures and outcomes among key interest groups.

The mental health and wellbeing outcome measures used were based on validated clinical diagnostic tools rather than on asking respondents to recall receiving diagnoses (of depression, for example) in order to minimise potential self-reporting bias. Flooding, even widespread flooding, has extreme variation in impact, rendering it difficult to establish a denominator for population exposure and outcome measures. Self-reporting of exposure and outcome is, therefore, acceptable and has been widely and successfully used in other studies of the health impact of weather-related events [18, 22, 73–76].

As data were not gathered on respondents' pre-existing mental health status, it remains uncertain how flood experiences may be related to mental health and wellbeing outcomes. However, two of the key mental health outcomes (*Still distressed about the flood*, and the measure of PTSD) were not about respondents' general mental health but were specifically about mental health following the flood, and the analysis will control for other aspects of mental health and wellbeing as well as for factors known to be associated with poor mental health such as low socio-economic status.

Conclusions

Presently, little is known about the association between river flooding and mental health and wellbeing outcomes in rural Australia. The study succeeded in recruiting a wide range of respondents, particularly in some of the key interest groups, and was committed to a community-academic partnership methodology. The partnership resulted in community engagement with the design and implementation and will assist with dissemination and use of findings. The study will provide a basis for a planned longitudinal cohort study to assess the short- (1–2 years) and medium-term (3–5 years) mental health and wellbeing outcomes of Northern Rivers' communities affected by flood and their associated needs, improving understanding of mental health and wellbeing effects over time. It will facilitate exploration of the elements of the proposed Flood Impact Framework, improving understanding of the path that links exposure to river flooding and mental health and wellbeing outcomes following flooding. This will, in turn, enable exploration of critical opportunities to strengthen services, emergency planning and resilience to future flooding. In sum, this study will provide an important and original contribution to understanding river flooding and mental health in rural Australia, a topic that will grow in importance in the context of human-induced climate change.

Abbreviations

ABS: Australian Bureau of Statistics; CAG: Community Advisory Group; LGA: Local Government Area; NSW: New South Wales (a State in Australia); PTSD: Post traumatic stress disorder

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Authors' contributions

JL, JB L, VM, HB, MP, GM, MR and RB designed the study. JL, VM, JB L, MP and MB facilitated data collection. VM, MP and MR analysed the data for this paper. JL led on the drafting of the work for publication and all authors critically reviewed draft versions and provided important intellectual content during revision. All authors, external and internal, had full access to all of the data in the study and can take responsibility for the integrity of the data. All authors accept accountability for the overall work and affirm that the manuscript is an honest, accurate, and transparent account of the study being reported and that no important aspects of the study have been omitted. All authors have read and approved the final manuscript.

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Availability of data and materials
The datasets used and analysed during the current study are available from The University Centre for Rural Health on reasonable request.

Ethics approval and consent to participate
The study was approved by the University of Sydney Human Research Ethics Committee (reference 2017/589) and the Aboriginal Health and Medical Research Council Human Research Ethics Committee (reference 1294/17). Potential respondents were advised that completing the questionnaire would be taken to mean their consent to participate in the study.

Consent for publication
This manuscript does not contain individual level data and thus this is not relevant.

Competing interests
All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare that they have no competing interests.

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Publisher's Note

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Exposure to risk and experiences of river flooding for people with disability and carers in rural Australia: a cross-sectional survey

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ABSTRACT

Objectives In this paper, we explore the exposure to risk and experiences of people with disability and carers during a flooding event and the subsequent mental health impacts.

Design A cross-sectional survey between September and November 2017. Binary logistic regression models were used to investigate associations between the mental health of people with disability and carers and their exposure to the flood. Inductive content analysis was used to analyse qualitative data.

Setting Flood-affected communities in the rural area of Northern Rivers, New South Wales, Australia, 6 months after river flooding in 2017.

Participants People over 16 years and a resident in the Northern Rivers at the time of the flood were invited to participate. Using a purposive, snowballing sampling technique participants were drawn from a wide range of socioeconomic backgrounds and had experienced different degrees of flood exposure.

Results Of 2252 respondents, there were 164 people with disability and 91 carers. Both groups had increased odds of having their home flooded (people with a disability: OR 2.41 95% CI 1.71 to 3.39; carers: OR 1.76 95% CI 1.10 to 2.84). On evacuation, respondents reported inaccessible, conflicting and confusing information regarding flood warnings. Essential services such as healthcare and social services were disrupted (people with a disability: OR 3.98 95% CI 2.82 to 5.60; carers 2.17 95% CI 1.33 to 3.54) and access to safe and mould free housing post flood event was limited. After taking sociodemographic factors into account, respondents with a disability and carers had greater odds of probable post-traumatic stress disorder compared with other respondents (people with a disability: 3.32 95% CI 2.22 to 4.96; carers: 1.87 95% CI 1.10 to 3.19).

Conclusion Our findings show the profound impact and systemic neglect experienced by people with disability and carers during and after the 2017 flood event in the Northern Rivers. As people with disability will take longer to recover, they will require longer-term tailored supports and purposeful inclusion in flood preparedness and recovery efforts.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study addresses an important gap in the literature on reporting how people living with disability and carers exposure to risk and experience of disasters such as fluvial floods in Australia.
⇒ As people with disability and carers may be difficult to reach, a study strength was the use of purposive sampling, utilising a snowball technique recruiting respondents via personal and local organisational networks.
⇒ Our sampling approach, though necessary to meet the aims of this study, constrains our ability to generalise our findings to the broader population.
⇒ Though brief versions of validated screening tools were used to assess psychological outcomes, they are not clinically diagnostic—our data, therefore, indicate 'probable' diagnoses.

INTRODUCTION

The severity and frequency of fluvial (river) floods are likely to increase as a result of a warming climate, intensified hydrological cycles and land development.[1–4] As climate change progresses, attention to the public health consequences of extreme weather events is urgently needed.[5–7] Weather-related disasters, including flooding, have been linked to increased prevalance of mental health disorders such as post-traumatic stress disorder (PTSD), anxiety and depression.[5 7–18] However, a systematic review by Fernandez *et al* concluded that there is limited mixed-methods research about the mental health impacts of fluvial flooding.[10]

Socially vulnerable populations are disproportionately impacted by flood events including home inundation, evacuation and displacement.[9 19–22] Viewed from a social vulnerability perspective, flood events intersect with social, cultural, economic and other factors (eg, age, gender, poverty and disability) to shape people's exposure to risk and their ability to prepare for, respond to and recover from extreme events.[23 24] Research grounded in this perspective posits that unequal disaster-related consequences

are experienced by different populations because of pre-existing disparities in the socioeconomic system. Individuals with disability and their carers are often among these populations as their circumstances render them vulnerable.[25]

There is an increasing body of literature on disability and disaster, mostly reporting North American research[26 27] with little Australian research on the topic.[28 29] Research shows that individuals with disability experience higher risk of death,[25 30] disruption to support networks,[31] injury and loss of property during floods,[32] increased challenges while evacuating[27 33 34] and sheltering.[35] These people also take longer to recover, requiring more intensive case management support postdisaster.[36–38] For example, in their examination of reports from disaster case workers, Stough *et al* found that while people with disability had the same postrecovery needs as others, they required far greater support in obtaining access to the services they needed, such as housing, medical services and transportation.[38 39] In comparison to research on people living with disability, the empirical research on how carers are impacted by weather related events is sparse,[40 41] and virtually non-existent regarding impact of fluvial flooding events.

We investigated the experiences and mental health impacts of river flooding on people with disability and carers, in an Australian rural location at 6 months postflooding. Specifically, we will answer the following research questions: (1) What were the associations between different flooding exposures and mental health impacts at 6 months after a major flooding event and (2) What was the likelihood and experience of being flooded, evacuated, displaced and having disrupted access to food, healthcare and social services? In doing so, we will enable identification of opportunities to mitigate risk and inform strategies to strengthen preparedness efforts, along with response and recovery to future flooding.

METHODS

Study setting

The Northern Rivers region of New South Wales, Australia, is a flood-prone rural area that experienced more than 30 flood disaster declarations between 2004 and 2014.[19] In 2017, ex-Tropical Cyclone Debbie brought record-breaking rainfall to the region that caused widespread flooding in local business districts and residential areas on a scale not seen in more than 40 years.[42] The Northern Rivers takes in areas with relatively high levels of social vulnerability.[21 43] There is a higher proportion of people with disability (24.8%) and carers (13.8%)[44] compared with the Australian average of 17.7% and 10.8%, respectively.[43] On average 6.5% of the Northern Rivers population required assistance with core activities compared with the Australian average of 5.1%.[44] Rolfe *et al* demonstrated that 82% of people living in the 2017 flooded areas in the town of Lismore (a major service centre in the Northern Rivers) were in the socioeconomically lowest quintile.[21]

Study design

This study draws on data from a cross-sectional survey undertaken between September and November 2017, 6 months after river floods in the Northern Rivers region, which included an exploration of the experiences and mental health outcomes of people with disability and their carers who experienced this flooding event.

A detailed description of the study design has been published elsewhere.[45] Design and reporting of our study was guided by the Strengthening the Reporting of Observational Studies in Epidemiology Statement[46] and the Standards for Reporting Qualitative Research.[47]

Patient and public involvement

This study benefited from being grounded in a community–academic partnership, which was key to its research design, implementation and dissemination/translation, particularly in facilitating recruitment and supporting respondents' participation. Further detail on this partnership can be found in the study protocol.[45]

Data collection

Community members who were 16 years and older and resident in the Northern Rivers at the time of the flood event were invited to participate regardless of whether or not they felt affected by it. We aimed to recruit participants from a broad cross-section of the community, with a wide range of socioeconomic backgrounds, and who had experienced different degrees of flood exposure. We used a purposive snowballing sampling technique, where community advisory groups and other community networks, service providers and local government staff assisted in promoting the survey and offered support and encouragement for people to complete it.[45] Given the known differential impact of flooding on socially vulnerable groups this approach was particularly important to ensure engagement of hard-to-reach, socioeconomically vulnerable populations groups such as Aboriginal and Torres Strait Islander people, people with disability and carers. The sampling strategy was therefore not intended to provide a representative sample of the broad Northern Rivers population, but rather to ensure participation by 'hard to reach' groups in the population.

To maximise participation in the survey a number of techniques were implemented including: leaflet drops and door-to-door data collection in a sample of random neighbourhoods in the most affected areas; social and local media campaigns; and a prize draw. The survey was available in online and printed formats.

The study cohorts were identified from two sociodemographic survey questions:

1. An income support question: 'At the time of the flood, were you receiving any income support from the government?' Respondents who reported receiving the Australian Government disability support pension or a carer's allowance were included. To be eligible for the disability support pension, an individual needed to be assessed as having a permanent physical, intellectual or

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psychiatric condition restricting their ability to work.[48] To be eligible for a carer's allowance the recipient had to be assessed as engaged in the constant care of someone with a severe disability or illness or who was frail aged.[49] Both support payments depended on the individual's level of income and assets (for carer support, this included both the carer and the receiver of care).

2. A multiple-choice question describing current circumstances if not in paid employment—for example, looking for paid work, in full-time education, looking after family/children—that included 'Unable to work due to long-term sickness or disability'. Respondents who selected this response option were added to the people with disability cohort, as it covered those who may not be eligible for the disability support pension.

Sample

A total of 2530 people responded to the survey, 278 (11%) of whom were excluded from data analyses because of missing carer or disability status data, leaving a final sample of 2252. A sensitivity analysis was conducted that showed minimal differences in the patterns of results between flood exposure and mental health outcomes for the full dataset and the dataset with missing sociodemographic records removed.[9] Seven per cent of respondents (n=164) identified as having a 'long-term sickness or disability' and 5% (n=117) were carers. There were 26 respondents who were both a carer and a person with disability. For this analysis, we ensured two mutually exclusive groups were identified, we therefore removed these 26 respondents from the 'carers' group (n=91) and retained them in the 'disability' group (n=164). This was a pragmatic decision based on people with disability being our primary group of interest.

Quantitative data

Sociodemographic data included age, sex, relationship status, employment status, type of income support payments received, and educational qualifications. The flood exposure measures included self-reported damage to the following sites: suburb; non-liveable areas of their home (eg, garden shed, garage); liveable areas of their home (eg, bedrooms); income-producing property (business/farm) and/or the home of a significant other.

Mental health status was assessed using brief versions of validated screening tools as they provide an efficient approach to identifying people at high risk of a mental health disorder. First, self-report measures for postflood distress included a single ongoing distress item from the Brief Weather Disaster Trauma Exposure and Impact Screen ('Are you still currently distressed about what happened during the flood?').[50] The measure was field-tested and used as part of the Queensland Government's annual Self-Reported Health Status survey after severe flooding in the summer of 2010–2011.[50] The yes/no 'still currently distressed' item from this measure was used in our analysis to allow for assessment of ongoing stress and anxiety related specifically to the flood event (as distinct from other possible causes of anxiety), and for comparability to other similar studies in which it has been used.[50]

The Post Traumatic Stress Disorder Checklist (PCL–6)[51] included a brief clinical screening tool (cut-point for probable diagnosis ≥14) that was introduced as a list of 'complaints' that 'people sometimes have' after severe rain and flooding. The PCL–6 has adequate diagnostic performance in primary care settings including for minority populations (sensitivity 80%–92%; specificity of 72%–76%).[52 53]

Box 1 Free-text opportunities in cross-sectional survey drawn on for this analysis

- ⇒ Q1—Is there anything on your mind that you want to say right up-front about the flood?
- ⇒ Q6b—(Did you have to evacuate your home?)If yes, is there anything more you want to say about this?
- ⇒ Q15g—(In your view, are any of the following organisations to blame for anyone's distress after the flood?)Is there anything more you want to say about this?
- ⇒ Q16a—(Were you in the Northern Rivers when the heavy rain fell in June 2017 (about 3 months after the March/April flood)?)If Yes: Did this affect you in any way? If so, how?
- ⇒ Q45—(Thinking back, have the severe rain and flood resulted in you being able to make any positive changes in your life?)If yes: could you give an example of your positive changes?
- ⇒ Q58—Is there anything else you want to add about your experience of the March/April flood or what things are like for you now?

Qualitative data

In the survey, there were six key opportunities for free text responses that explored respondents' experience of the flood event and perceptions of how they were impacted by it. These opportunities are described in box 1.

Free-text responses were provided in at least one of the eight opportunities by 153/164 (93%) respondents with disability and 80/91 (88%) carers. Responses to each free-text opportunity in the survey ranged from a short sentence to several paragraphs.

Analysis

Unadjusted binary logistic regression models were used to calculate the odds of experiencing flood exposure (damage to non-liveable areas, liveable areas and evacuation and length of displacement) for respondents with a disability and carers relative to other respondents. For binary logistic regressions comparing mental health outcomes (still distressed and probable PTSD) between our key interest groups and other respondents, we adjusted models to take into account all measured sociodemographic characteristics (age, gender, education level and employment status) as well as flood exposure (cumulative exposure index for individuals by summing the number of self-reported damage sites: suburb; non-liveable areas of their home (eg, garden shed, garage); liveable areas of their home (eg, bedrooms); income-producing properties such as businesses or farms; and

home of a significant other).[45] Respondents who did not complete a health outcome measure were excluded from analysis for that indicator only. Stata V.15 software[54] was used for analysis with the significance level set at p<0.05.

To code and analyse the qualitative data systematically and comprehensively, we used inductive content analysis[55] using the software QSR NVivo V.9[56] to facilitate the organisation and coding of data. Guided by Elo and Kyngäs[55] the following steps were undertaken to ensure rigour: (1) JB and JL (two experienced qualitative researchers) immersed themselves in the data and independently read and re-read the data to get a sense of the whole, that is, to gain a general understanding of respondents' free text comments; (2) JB inductively open coded the data, writing notes and headings that described the content; (3) drawing on the notes and headings, JB developed a set of 'meaning units' (or categories); (4) through a process of comparison and rereading of data JB grouped similar categories that were perceived to belong together and developed a broader set of categories; (5) JL used the same procedure and inductively coded approximately 70% of the data independently; (6) two reviewers (JB and JL) then conferred in person to deliberate on the interpretation, resolve disagreements through discussion and identify patterns; (7) JB then applied the agreed set of categories across the whole dataset. The process was iterative and involved several reflection sessions between JB and JL discussing similarities and differences between accounts to ensure different perspectives were included.

Based on their experience as original members of the flood study team and as experts in the field, all authors checked the results to ensure they were consistent with their perceptions and understanding. Only minor adjustments were required to achieve good concordance between authors in the categorisation, analysis and interpretation of the data. To ensure that the voices of this often overlooked group were heard, we have provided a series of exemplar quotes to support the categories.

RESULTS

Respondent characteristics

Of the 164 respondents in the 'disability' group, 64% were female and 70% were aged 45–64 years. Of the 91 respondents in the 'carers' group, 80% were female and 53% aged 45–64 years (table 1). An apparent social gradient from respondents with disability to carers to 'others' is suggested by the proportions of each group with a university degree or in employment. Respondents with a disability were significantly less likely to be employed compared with other respondents (43% vs 88%, respectively) and were more likely to have lower educational qualifications.

Increased flood exposure

Respondents with disability and carers had around twice the odds of their internal living areas of their homes flooded compared with other respondents (people with a disability: OR 2.41 95% CI 1.71 to 3.39; carer: OR 1.76 95% CI 1.10 to 2.84) (table 2).

As housing in flood-prone areas is generally cheaper to buy and to rent, respondents raised concerns that people with the least resources, including those with disability and carers were at times living in accommodation that placed them at particular risk of flooding.

> Some of my friends lived in places in the centre of Lismore CBD that perhaps should never have been rented due to the vulnerability of their buildings in floods. These type of rooms/places were really vulnerable in the flood, it would have been impossible to get possessions to safety quickly enough. And people who rent these type of places have the least resources (mental, emotional, physical (cars etc.), financial) to cope with this type of event quickly. (Person with disability, No. 243)

Likelihood and experience of evacuation

Respondents with disability had over twice the odds of having to evacuate compared with other respondents

Table 1 Sociodemographic profile of survey respondents with disability, carers and others (respondents who were neither)

		People with disability (n=164)	Carers (n=91)	Others (n=1997)
		n (%)	n (%)	n (%)
Age group	16–24	5 (3.1) ***	5 (5.6)	102 (5.2)
	25–44	31 (19.1)	22 (24.4)	486 (24.7)
	45–64	113 (69.8)	48 (53.3)	999 (50.7)
	65+	13 (8.0)	15 (16.7)	385 (19.5)
Gender	Women	103 (64.4)	72 (80)	1357 (68.9)
	Men	57 (35.6)	18 (20)	614 (31.2)
Education level	University degree	37 (23) ***	36 (40)	904 (45.7)
	Other	124 (77)	54 (60)	1076 (54.3)
Employment status	Paid employment (part or full time)/retired	69 (42.6) ***	64 (71.1) ***	1741 (88.2)
	Not employed	93 (57.4)	26 (28.9)	234 (11.9)

Chi-squared analyses: the proportion of respondents with a disability/carers is significantly different than the proportion in other respondents (***P<0.0001).

Table 2 ORs of flood exposure and mental health outcomes for respondents with a disability and respondents who are carers compared with other respondents

Respondent category	Person with a disability (n=164)		Carer (n=91)		Others (n=1997)
Flood exposure	n(%)	OR† (95% CI) (Ref=others)	n (%)	OR† (95% CI) (Ref=others)	n (%)
Non-liveable area flooded (yard/garden)	59 (37.6)	1.93 (1.39 to 2.69)***	390 (20.0)	1.92 (1.24 to 2.97)**	390 (20.0)
Liveable area of home flooded	101 (62.4)	2.41 (1.71 to 3.39)***	911 (46.1)	1.76 (1.10 to 2.84)*	911 (46.1)
Home evacuation	47 (29.4)	2.46 (1.71 to 3.54)***	285 (14.5)	1.38 (0.80 to 2.37)	285 (14.5)
Displaced <6 months	31 (18.3)	0.58 (0.30 to 1.10)	199 (10.0)	0.74 (0.25 to 2.21)	199 (10.0)
Displaced ≥6 months	18 (11.4)	3.78 (2.18 to 6.55)***	63 (3.2)	1.78 (0.70 to 4.54)	63 (3.2)
Long time for help to arrive	28 (17.3)	3.25 (2.08 to 5.09)***	119 (6)	2.14 (1.11 to 4.13)*	119 (6)
Disrupted access to health/social care	62 (38.3)	3.98 (2.82 to 5.60)***	266 (13.5)	2.17 (1.33 to 3.54)**	266 (13.5)
Disrupted access to food	53 (32.7)	2.06 (1.45 to 2.91)***	377 (19.1)	1.60 (0.99 to 2.57)	377 (19.1)
Mental health outcomes		aOR‡ (95% CI)		aOR‡ (95% CI)	
Still distressed	67 (40.9)	1.76 (1.18 to 2.63)**	250 (12.8)	0.84 (0.49 to 1.44)	250 (12.8)
Probable PTSD	65 (40.1)	3.32 (2.22 to 4.96)***	419 (21.3)	1.87 (1.10 to 3.19)*	419 (21.3)

*P<0.05; **p<0.01; ***p<0.001.
†Unadjusted OR.
‡aOR for other sociodemographic variables (age, gender, education level and employment status) and severity of flood exposure.
aOR, adjusted OR; PTSD, post-traumatic stress disorder.

(OR 2.46 95% CI 1.71 to 3.54) (table 2) due to their increased flood exposure. In the qualitative data there were numerous reports of people evacuating late (or not at all). When people with disability wait too long it causes challenges because there are inadequate resources in the emergency sector to evacuate everyone. Respondents reported taking longer to evacuate due to a lack of transport and the extra time needed to pack and move additional equipment, as well as sensory challenges and the disruptions to their routine.

> … when we did evacuate it was late because we were worried about our children … one who is autistic and is easily stressed when routines are disrupted. (Carer, No. 13)

There were also commonly reported challenges with information related to evacuation orders and flood warning systems, as well as poorly timed, conflicting or incorrect warnings regarding flood water levels and the possible need for evacuation. Respondents identified that at times they did not understand the messages they were given and so struggled to make effective decisions, for example:

> Didn't know what evacuation meant for example, what to take, would I have to stay there, where to go… Had no idea what river levels meant, for example, Tweed River is 4.3m. (Person with disability, No. 154)

It was reported that deaf people were given oral directions that were not accompanied by sign language, and some reported not being able to hear the warning sirens. These communication barriers affected how quickly people became aware of the extent of the flooding, the need to evacuate, access to emergency information during the flood event and their ability to seek assistance.

> I got no warning but TV said evacuation for [the] CBD, and when I rang SES for information I could not get through. I needed clarification for my family and I have 3 special needs kids and I needed help to evacuate … I said I need help! I was told no help for me as I was under order to evacuate hours before but no one rang, no one knocked on my door! [My house] was completely destroyed. Knocked off the pylons, condemned [to] a horrific night of hell getting the kids out by myself. (Carer, No. 67)

A number of carers described the importance of sensitive communication by emergency services tasked with providing evacuation orders. The quote below reflects a number of responses to the order to evacuate well in advance, and the challenge in responding to this order for people with additional support needs.

> … some representatives of the emergency services would not listen to people who have lived through many floods. To expect infirm, aged or carers of disabled to move to other premises is silly. As an aged person with rather dicey balance, and having a disabled son equally as awkward, to demand they evacuate is difficult to achieve. Large, and larger, pillows, blankets, 5 medications, an aged cat—and where and when and how and what happens then? (Carer, No. 177)

Likelihood and experience of displacement

Respondents with disability had almost four times the odds of being displaced for more than 6 months than others (OR 3.78 95% CI 2.18 to 6.55). As people with disability were more likely than others to have their homes flooded, and to be evacuated and displaced, there was a reported increased need for alternative housing for both the short and the long term, and for assistance to access such housing. As a result, housing vulnerabilities were evident. Respondents identified a lack of affordable accommodation for displaced people with disability and carers, which resulted in some living in unsafe accommodation (eg, mould, no cooking facilities and structural damage), relocating to other areas (with the subsequent loss of their support networks) or even becoming homeless.

When so many houses are flood damaged, a lot of people are displaced from lower cost housing, which leads to a lack of affordable accommodation. With many more people looking for accommodation, high levels of financial stress were reported:

> Where the flood did affect me was the housing crisis born of a shortage of rental properties. I was given notice to move from my rental property just before the flood. It was extremely tough to find anything affordable on the pension (& with pets) in the months after. I am currently in temporary accommodation till March, then who knows? (Person with disability, No. 168)

Accessing help at the time of the flood and support for recovery

Respondents with disability and carers were more likely to report that the help they needed took a long time to arrive in comparison to other respondents (people with disability: OR 3.25 95% CI 2.08 to 5.09; carer: OR 2.14 95% CI 1.11 to 4.13)

There were many reports of respondents feeling they had been left to fend for themselves and experiencing frustration with getting assistance in the form of financial disaster relief measures, help with cleaning up and accessing services.

> The lack of help for the homeless and vulnerable. The anxiety and stress that occurred and the amount of people left homeless and still trying to find a home 5 months later. Services that were desperately needed but were very hard to find. (Person with disability, No. 1)

There was a reported perception that recovery supports were not available or accessible to people with disability in ways that they could use to take action, to keep safe and to recover. In one instance for example, a respondent had to relocate to another area so missed accessing crucial information about recovery assistance and grants as the information was sent to their impacted home. A number of respondents reported difficulty navigating the paperwork to enable access to recovery support.

Losing connection to support networks and access to essential services

Respondents with disability were more likely to report disrupted access to essential services, such as health, social care (OR 3.98 95% CI 2.82 to 5.60) and food (OR 2.06 95% CI 1.45 to 2.91), in comparison to other respondents (table 2). In free-text responses, respondents reported barriers to accessing essential services that included disrupted banking facilities, road blockages and damage due to flooding, closed businesses, reduced opportunities for community participation and, importantly, disruption to support networks.

Disrupted support networks further hampered access to essential services and often resulted in social isolation, with reports of paid support staff being affected by flooding themselves and then not being able to support their clients. It was reported that further disruption occurred when some paid support staff had to move away from the area because they could not secure affordable accommodation after the flood event.

> … one of my son's Carers (he has severe autism and needs one on one attention at all times) was flooded out of her home and her car was destroyed. …She is going to be leaving the area, as a result of losing her home, and while this obviously most affects her, it greatly affects us, and particularly my son, as she has been one of his carers since he was an infant. We will greatly miss her as a friend, but even more importantly, as a very important part of our family system and for our son. (Carer, No. 12)

Social connectivity was identified as a supportive factor for respondents with disability in terms of their mental health and of being able to access assistance. Some respondents reported that people with disability who were viewed by community and emergency workers to be well connected to the community, or 'visible and well known', received wider community support in accessing essentials such as food.

Mental health impacts

After taking sociodemographic factors into account, carers and respondents with a disability had twice and three times the odds of probable PTSD compared with other respondents respectively (table 2). Respondents with a disability were also more likely to report still being distressed about the flood in comparison to other respondents (OR 1.76 95% CI 1.18 to 2.63) (table 2).

Analyses of the qualitative data illustrated how the flood event also compounded existing physical and mental health issues, which led to profound and long-lasting impacts.

> I miss my daily chats at the now closed newsagency. We lost 3 newsagents as they have not reopened. My whole support network was turned upside down. My PTSD condition worsened during and after the flood. (Person with disability, No. 34)

Mental health symptoms linked to the floods (table 2) further impeded access to services:

> The shock of the flood made it difficult to get out of the house to pursue assistance or get informed. (Person with disability, No. 249)

DISCUSSION

Our study found that people with disability and carers were more severely affected by the flood event, as they were more likely to have the living areas of their homes inundated and to experience far greater disrupted access to essential services such as flood recovery efforts, healthcare, social services and food in comparison to others. In addition, respondents with a disability were more likely to be evacuated and experience lengthy displacement. As a result, respondents had more need for alternative short-term and long-term housing. Furthermore, with longer term displacement (which is particularly deleterious to mental health),[9] respondents were significantly more likely to report that, 6 months after the flood event, they were still distressed and experiencing probable PTSD.

Our findings are also in keeping with those of previous studies describing barriers to evacuation,[57 58] which include inaccessible, conflicting and confusing information, and poorly timed or incorrect warnings regarding flood-water levels and the possible need for evacuation. Thus, it is vital that government and emergency services address these barriers to evacuation through better and more targeted early warnings, and working in partnership with the community, trusted leaders and groups to communicate those warnings and improve the response to them. By making this information available and accessible in ways that people with disability can take action to keep safe, the expectations on emergency services that cannot currently be met will be mitigated.

Access to safe, mould-free and affordable housing was a significant issue highlighted in our study. Similarly, Stough *et al*[38] and Fox *et al*[59] identified that post disaster, people with disability experienced difficulties in obtaining housing that is accessible in both the short and long term. Recovery barriers included a perceived lack of, or conflicting, information, and difficulty navigating the paperwork required to apply for assistance. Following a disaster, people with disability must navigate two complex and often inaccessible bureaucracies: the emergency response and recovery arrangements and disability services. Stough *et al* state 'that a salient difference in the disaster experience of individuals with disabilities is the considerable and unique complications that they confront in accessing disability-related services and resources after a disaster.'[38] As many people had to relocate, accessing information became even more of a challenge. Disability support staff and services themselves were compromised and disrupted by the flood event which further exacerbated problems with prompt access to recovery and support services.

Mental health concerns were cited as a barrier to recovery, as they specifically impacted on people's ability to navigate the systems needed to aid recovery. These findings are consistent with current research highlighting that people with disability will take longer to recover from weather-related disasters, and require longer term tailored supports during that period.[8 36 39] The finding that people with disability and carers were more likely to have probable PTSD 6 months after the flood event highlights the need to raise awareness among all social and healthcare professionals of the longer-term psychological impact of traumatic events .[60]

People with disability and carers are disproportionately impacted by floods and there have been calls for more disability-inclusive responses to weather-related events.[40 57 61] The need for greater investment in preparedness is amplified in areas where disasters are likely to occur again and where the most socially marginalised populations reside. For example, as the occurrence and severity of floods in the Northern Rivers region will likely increase due to climate change, those who are most socioeconomically disadvantaged will be more affected as they live in flood-prone areas.[21] Thus, emergency management approaches need to take into consideration the profile of communities in high flood risk areas, and develop plans that target more effective risk communication, preparedness planning, disaster warnings and support to access recovery services.

Our findings clearly support recommendations for an increasing focus on disaster prevention and preparedness.[62 63] The vulnerability of people with disability and carers is further increased because they have not been included in community-level disaster preparedness.[37 57 64 65] Person-centred preparedness conversations, for example, would help people with disability to be involved in planning how they will respond in an emergency situation. To this end, Australian researchers, in partnership with stakeholders from the disability, community and emergency services sectors, have codesigned a Person-Centred Emergency Preparedness (P-CEP) model[57 64 66] to support more effective and systemic responses.[67] This strengths-based model has a suite of tools available to assist people with disability, carers and service providers to develop emergency preparedness plans through self-assessment, targeted actions and advocacy relevant to their support needs they in an emergency, and to support individuals to take ownership of these plans.[57 64 66] P-CEP emphasises the roles of multiple stakeholders in reducing disaster risk, rather than restricting actions to those of government and emergency services to protect people with disability and carers.[67]

In this context of the importance of preparedness to mediate the impact on people with disability it is of concern that little attention has been given to the scarcity of disability data,[68–70] which is a crucial underlying factor that precludes movement towards inclusion and, ultimately, addressing inequities.[38 69 71] Stough *et al*[38] identified that most jurisdictions have only a very limited idea

of how many people with disability live or work in flood-prone areas. Without these data, the impact of events such as floods on people with disability remains difficult to address and perpetuates their exclusion.[69 71]

Improving outcomes for people with disability and carers post flooding cannot be achieved without also challenging the inequities they experience in all aspects of life. Although their vulnerability is often attributed to personal cognitive or physical abilities, many respondents in our study focused on the social and structural factors that precluded inclusion as being problematic in the evacuation and recovery process—such as lack of transport, difficulty navigating postrecovery systems, poor access to alternative housing, etc—rather than on their own characteristics. This is in line with social vulnerability theorists who conceptualise vulnerability as the result of pre-existing barriers and exclusionary social practices, rather than as an attribute of the person.[23] Similarly, although we do not deny the significance of floods as trigger events, we do emphasise the various ways in which social systems operate to make people vulnerable to the risks posed by extreme weather-related events such as floods.

Carers play a vital role in providing support for people with disability, and yet their experiences during and after flood events, and the impacts on them, has received very limited attention.[40] Given the disproportionate impacts that carers experience from flood events, it is important that they are identified as a key interest group. This finding is consistent with Pickering *et al* who in a recent scoping review highlighted the need for more research and purposeful inclusion of carers in disaster preparation and recovery.[40] What is clear from our study is that both groups—people with disability and carers—require targeted strategies that will address their specific needs before, during and following an emergency, such as a flood, including supporting their preparedness. There is, therefore, a particular need for further research into the impacts on, and experiences of, carers during such events.

Strengths and limitations

This study addresses an important gap in the literature on reporting how people living with disability and carers experience disasters such as fluvial floods in Australia. Our identification of respondents with disability and carers was restricted to those who indicated they could not work due to long-term disability or illness (including via receipt of the disability support pension) and those eligible for a government carer's allowance, respectively. We recognise that there are varying types of disability, and we may have excluded other respondents with impairments that do not necessarily limit their employability but could interfere with their capacity to prepare and respond adequately in an emergency situation (eg, those with sight/hearing loss, mobility issues). Similarly, we may have excluded other carers who were not eligible to receive the government allowance. As receipt of a disability support pension is income and assets dependant, the inclusion of the demographic question 'unable to work due to long-term sickness or disability' enabled us to capture people ineligible for the government disability allowance due to income and asset restrictions and people. This question was unpiloted and did not include follow-up questions addressing the nature of impairment or functional limitations experienced by respondents, this information would have been helpful in further understanding the flood impact on people with different types of disability or support needs.

Our sampling approach was not intended to estimate population prevalence for measures related to exposure or outcome. Self-selection bias may have resulted in those who had been affected by the flood event participating in the survey. Furthermore, the survey relied on self-reported data that may affect the accuracy of the information.

While we lacked a mental health baseline prior to the flood, we included two measures specifically related to the flood and we adjusted for socio-demographic factors known to predict mental health. The literature points to people with disability[72] and carers[73 74] as having elevated rates of mental health disorders compared with the general population. To address this, we used validated screening tools and analysis techniques that allowed for an assessment of ongoing stress and anxiety related specifically to the flood event (as distinct from anxiety arising from other causes). Brief mental health disorder screening tools have useful applications and are widely used by clinicians and researchers as they provide an efficient method to query symptom areas requiring further assessment or research.[75] They are, however, not a substitute for full diagnostic criteria.[76] Therefore, this study must be viewed in the light that we used brief screening tools as opposed to a full clinical assessment.

A particular strength of our study was the community–academic partnership, in which we used local community and organisational networks to document experiences of socioeconomically marginalised respondents that included people with disability and carers.[45] Despite these efforts, the relatively small number of respondents with disability and carers reduced statistical power and may have meant some important associations were not shown to be statistically significant. Though the survey was available in several formats and efforts were made by organisation who were part of our community–academic partnership to assist people to complete the survey, the survey may still have been inaccessible for some people.

CONCLUSION

The 2017 flood event in the Northern Rivers highlighted the profound impacts and systemic neglect experienced by people with disability and their carers during and after the flooding in the region. We found people with disability and carers are more likely than others to be affected and displaced, their needs are more immediate and urgent than most, and their mental health is more likely to be compromised. As people with disability will take longer to

recover, they will require longer term tailored supports. Our research provides compelling evidence that more needs to be done to ensure their purposeful inclusion of people with disability and carers in both flood preparedness and recovery efforts.

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Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

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Cross sectional analysis of depression amongst Australian rural business owners following cyclone-related flooding

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Abstract

Background: Flooding is an increasingly prevalent natural hazard worldwide and can have a profound impact on the mental health of those directly and indirectly affected. Little is known about the impact on business owners, who may be particularly vulnerable to the mental health complications of flooding given the additional economic stressors.

Methods: A large cross sectional survey was conducted six months after severe flooding in the rural Northern Rivers region of New South Wales, Australia in 2017. The survey assessed demographics, probable depression (using the Patient Health Questionnaire 2), flood exposure, flood related financial factors, prior flood exposure and support from various organisations. Logistic regression was used to identify predictors of probable depression in 653 of the 745 participants who identified as business owners.

Results: The prevalence of probable depression in our sample was 17.0%. A quarter (25.1%) of business owners whose business was flooded suffered from probable depression, compared to 12.4% of non flooded business owners. The multivariable model for probable depression demonstrated elevated adjusted odds ratios (AOR) for business owners who had to evacuate their business (AOR = 2.11, 95% Confidence Interval (CI) 1.25–3.57) compared to those who did not evacuate. Insurance disputes/rejections were a strong predictor for probable depression (AOR = 3.76, CI 1.86–7.60). Those whose income was reduced due to the flood and had not returned to normal six months post flood demonstrated an increased AOR for probable depression (AOR 2.53, CI 1.26–5.07) compared to those whose income had returned to normal. The univariable analysis found elevated crude odds ratios (OR) for the cumulative effect of multiple flood exposures and unmet support needs by the state government (OR = 2.74, CI 1.12–6.68). The majority of business owners felt their needs were not met by most organisations providing flood related support.

Conclusion: The impact of flood exposure and flood related financial factors on probable depression was highly significant for the business owner population. Furthermore, business owners felt under supported by flood related services. These findings highlight the vulnerability of exposed business owners and the need for increased support. Disaster planning programs in conjunction with system level changes such as infrastructure and education are vital for disaster preparedness.

Keywords: Natural disasters, Mental health, Business, Insurance, Depression, Floods

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Background

Flooding is a prevalent and expensive hazard around the world, and in Australia is responsible for the largest economic cost of any natural disaster per annum. These costs consist of damages to infrastructure, agriculture, business and housing, as well as intangible costs in health, social and cultural losses [1]. Floods can have a profound impact on the health of those directly and indirectly affected [2, 3]. These health impacts can include physical injuries, lack of access to healthcare and medications and mental health problems such as post-traumatic stress disorder (PTSD), anxiety and depression [2–4]. Depression is one of the most common mental health consequences of flooding, and some studies show prevalence rates higher than PTSD, up to 35.1% of affected populations [5]. PTSD is less common following natural disasters compared to human-caused disasters according to a 2018 meta-analysis [6]. Furthermore, PTSD-like symptoms, even without meeting the criteria for PTSD diagnosis, can lead to the development of other psychiatric conditions including depression [2]. Therefore due to this striking prevalence, depression can not be ignored as a vital outcome measure that needs to be studied in this context.

Post-disaster, business owners face additional economic pressures as well as the problems which affect the general population [2, 7]. Some of these economic pressures include loss of income, stock and equipment damage, rebuilding issues, insurance matters, loss of electricity and customer and employee shortages [7]. Depressive symptoms are increased in the general population following flood exposure, [2] and we postulate that due to these economic stressors, business owners may be at an increased risk. Therefore, studying this potentially vulnerable group is vitally important to assess mental health outcomes and suggest solutions to address these outcomes. To our knowledge there is no research surrounding the post-flooding mental health of business owners, however there is some limited evidence following natural disasters other than flooding. A Sri Lankan study found that following the 2004 tsunami in Southeast Asia, poor initial mental health was strongly correlated with degree of economic loss. However, mental health recovery was not associated with economic recovery. In this study, mental health was measured using questions related to “return to normalcy” in life and “change in life outlook”, which correlated with the Mental Health Inventory (MHI-5) and the DSM-IV screening questions for PTSD [8]. A Thai study that also looked at the 2004 tsunami found that those who suffered loss of business had significantly poorer mental health outcomes at one year post-tsunami, compared to the unaffected population. Mental health outcomes were assessed in this study using the Short Form Health Survey (SF-36) [9]. However, it is difficult to make direct comparisons from the aforementioned studies due to the different type of natural disaster, the developing country context and the large scale of mortality, morbidity and destruction of the 2004 tsunami.

In light of the complex relationship for business owners between mental health recovery and economic recovery, it suggests that other factors may impact mental health outcomes amongst this group. A number of factors have been identified as having an association with poor mental health outcomes post-flood. Amongst the general population affected by flooding, the degree of flood exposure damage has repeatedly been shown to correlate with poorer mental health. A similar relationship has been found with financial factors such as socioeconomic status and economic losses. On the other hand, both age and gender have yielded inconsistent results [2].

The Northern Rivers region in New South Wales (NSW), Australia, is particularly prone to flooding, with seven major floods documented since 1857 [10]. The most recent event was severe flooding in March 2017 due to heavy rainfall following cyclone Debbie [11]. In Lismore (a large population centre in the region), the levee (constructed in 2005 to protect the Central Business District) was overtopped for the first time, inundating businesses in the town centre [12]. We postulate that this trauma will have had a significant impact on the community and warrants extensive research. Following the March 2017 flooding, to assist business owners, several supports were made available from various sectors including: local volunteer assistance to clean away flood debris; local council and community organisations’ emergency food and shelter assistance; local council and church sponsored business chaplaincy program for emotional and wellbeing support; and state government financial assistance specifically targeted at small business.

This study aims to inform the literature gap surrounding business owners by investigating a number of factors that may influence depression post-flooding in this vulnerable group. These factors include 2017 flood exposures such as business flood and evacuation status, evacuation warning times and home flood status, as well as flood-related financial factors such as insurance disputes/rejections and the flood effect on income. We also investigated factors such as demographics, prior flood exposure, and satisfaction with support received from various organisations post-flood.

Methods

Data collection

A cross sectional survey was conducted online and in paper form from September to November 2017 in the Northern Rivers, in North NSW. Recruitment and sample size estimation has been described in detail in a separate paper [13]. The survey was executed in response to flooding in the region in March 2017, six months prior. This survey targeted residents aged 16 years and over, in six local government areas with a total population of approximately 250,000 as of 2018 [14]. Participants were recruited via

a snowballing distribution technique, utilising community groups, service providers, local government and local businesses. As the purpose was to investigate relationships between mental health and flooding, rather than to evaluate population prevalence, this purposive sampling recruitment method was appropriate and facilitated the targeting of groups of interest including business owners [13]. Additionally, social media and local media were used to increase survey awareness, and a prize draw with gift vouchers to encourage participation. These techniques were supplemented with door-to-door data collection in randomly selected neighbourhoods in the most affected areas and leaflet drops. Respondents were deemed to have provided consent by returning a questionnaire [13]. The online survey was created using Qualtrics software (version Sept–Nov 2017, Qualtrics Provo Utah).

Measures

The survey included questions regarding basic demographics, mental health, 2017 flood exposure, flood-related financial factors, prior flood exposure and flood-related support needs.

Demographic factors

Demographic factors included age, gender, place of birth, Aboriginal and Torres Strait Islander status, relationship status, education level, current work status, annual household income, and housing status at the time of the flood.

Outcome measure: probable depression

The outcome measure, probable depression, was assessed using the Patient Health Questionnaire (PHQ-2), a validated diagnostic tool with scores ranging between 0 and 6. Respondents who scored ≥3 were categorized as having probable depression [15].

2017 Flood exposure

Flood-related factors included business flood status (flooded or not flooded), level of water in the business (not flooded, water in some areas but not all of the business, water below knee in entire business, water between knee and head height in entire business or water above head height in entire business), evacuation status (evacuated or not evacuated) and warning given to evacuate in hours. Non-business flood exposures were also assessed: liveable areas of the home flooded, evacuation status and displacement from home.

Flood-related financial factors

Two flood-related financial factors were included: income reduction due to the flood and insurance disputes/rejections despite believing they were fully insured.

Previous flood exposure damage

Prior flood exposure included exposure to floods in the Northern Rivers, or damage due to floods in other areas.

Flood-related support

Flood-related support needs were assessed by asking whether participants felt their needs were met by the state government, local council, community organisations, insurance companies, emergency services and volunteers/neighbours. Needs were classified as "met" or "unmet" for these variables. Those participants who answered "don't know" or "not-applicable" were coded as missing.

Cumulative effect variables

Cumulative effect variables were derived from existing variables to provide information regarding the impact of compounding exposures on mental health. The "business cumulative effect" variable was calculated by combining business flood status and business evacuation status so that participants were rated as having neither exposure (neither flooded nor evacuated), one exposure (flooded or evacuated) or both exposures (flooded and evacuated). Similarly, a "business and home cumulative effect" variable was calculated by combining business flood status and home flood status.

Sample

The survey had a total of 2530 responses including business owners and non-business owners. The final sample was composed of respondents who identified themselves as a business owner and who completed the primary outcome measure (probable depression). Farmers were excluded from this group, which left 745 valid responses. Ninety-two responses were excluded due to missing data leaving 653 responses for the univariable and multivariable logistic regression. The samples for the six flood-related support needs variables excluded participants who answered "don't know" or "not-applicable" leading to samples ranging between 304 and 436 respondents.

Statistical analyses

The categorical demographic characteristics, 2017 flood exposure factors, flood-related financial factors, prior flood exposure and supports provided were calculated on the sample of 745. Chi square tests of association of these categorical characteristics with the binary outcome of having probable depression were conducted.

Univariable logistic regression models for probable depression were assessed using demographics, 2017 flood exposures and financial factors for participants with complete data ($n = 653$). Any characteristic which was associated with probable depression with a $p < 0.10$ was included in the univariable and multivariable logistic regression models. The model building process was made up of three steps with inclusion of i) demographic factors ii) 2017 flood exposure and iii) financial factors. Variables were included in the final model if they demonstrated an increase in the Nagelkerke R square, demonstrating improved model fit.

The following variables were excluded from the model due to collinearity: current work status (association with household income); business flooding status and water level (association with business evacuation); insurance company support needs (association with insurance disputes/rejections); and home evacuation and displacement (association with liveable area of the home flooded). The association by chi square of these collinear variables is seen in Appendix 1 in Table 7.

Cumulative variables were not included in the multivariable models in favour of the individual variables which comprised them. A second multivariable model is displayed in appendix (Appendix 2 in Table 8) that includes the business cumulative effect variable. Support needs variables were analysed separately, and all were included in univariable logistic analysis. When support factors were included in the multivariable model, after adjusting for demographics, flood exposure and financial factors, none retained significance so were not included in the final logistic model. This is with the exception of the insurance company support needs variable, which was excluded due to collinearity with insurance disputes/rejections. The odds ratios (OR) and adjusted odds ratios (AOR) were reported with 95% confidence intervals. A p value < 0.05 was considered to indicate statistical significance, no adjustments were made for multiple comparisons. The statistical program SPSS (Version 25, Armonk, NY: IBM Corp.) was used for data analysis.

Ethics

Ethics approval was granted by University of Sydney Human Research Ethics Committee and the Aboriginal Health and Medical Research Council Human Research Ethics Committee (Ethics ID 2017/589 and 1294/17 respectively). Completion of questionnaire was taken as informed consent.

Results

Demographic characteristics

Of the 745 business owners, 67.2% were female and 46.4% were aged between 35 and 54 years. Gender was associated with probable depression, with 24.6% of male compared to 13.8% of female respondents having probable depression. Aboriginal and Torres Strait Islander status was also associated with probable depression with 56.0% (14/25) of Aboriginal and Torres Strait Islander respondents having probable depression compared to 15.6% (110/705) of non-Indigenous respondents. Similarly, single relationship status, lower education, current work status (unemployment), lower annual household income and housing status at the time of the flood were all found to be associated with probable depression. Age and place of birth were not significantly associated with probable depression (Table 1).

Flood exposure, flood-related financial factors and previous flood exposure

The following 2017 flood exposure factors were found to be significantly associated with probable depression: business flood status, business evacuation, level of flood waters in business, home flood status (liveable areas), home evacuation and any length of displacement from home. The overall prevalence of depression amongst respondents was 17.0%. Of those business owners whose premises were flooded 25.1% reported probable depression, compared to 12.4% of non-flooded business owners. Similarly, 24.5% of those whose businesses were evacuated reported probable depression compared to 12.8% of those who were not evacuated. In contrast, warning time given by emergency services to evacuate business was not associated with probable depression. Both the business cumulative effect, and business and home cumulative effect were significantly associated with probable depression, where increased levels of exposure resulted in higher rates of probable depression. Flood-related financial factors, including insurance disputes/rejections and effect of flood on income, were also strongly associated with probable depression. Prior flood exposure damage appeared not to be associated with probable depression (Table 2).

Perceived support needs

Table 3 demonstrates the perception of flood-related support needs. Overall, business owners were most likely to feel their needs were met by volunteers/neighbours (56%), followed by community organisations (39.1%) and emergency services (36.2%). However, a large a number of participants answered "don't know" or "not-applicable" to these questions and were therefore excluded from data analysis presented in Table 3. The odds for probable depression in those with unmet needs was always higher than that of met needs, but was only statistically significant for support from State Government or insurance companies. Business owners who felt that the state government or insurance company did not meet their needs had almost three times the odds of having probable depression (OR = 2.74, CI 1.12–6.68 and OR = 2.78, CI 1.26–6.13 respectively) compared to people who thought their needs had been met.

Univariable logistic regression

Table 4 presents the univariable logistic regression results for the demographic factors. The following factors all demonstrated increased OR for probable depression: respondents who were male, Aboriginal and Torres Strait Islander, single, those who are currently unemployed, those with a household income of <$50,000 per annum and people who were renters at the time of the flood.

Table 5 presents the univariable logistic regression for the 2017 flood exposure factors, including cumulative variables, and flood-related financial factors. People's whose businesses had been flooded or whose business had been evacuated had more than twice the odds of probable depression compared

Table 1 Demographic characteristics and association with depression amongst business owners ($n = 745$)

Variable	Total		Probable Depression		*P* value
			No *N = 618 (83%)*	*Yes* *N = 127 (17%)*	
	n	%	n (%)	n (%)	
Demographics					
Age ($n = 733$, missing = 12) *Chi square value = 4.38, df = 2*					
16 34 years	95	13	78 (82.1)	17 (17.9)	0.112
35 54 years	340	46.4	272 (80)	68 (20)	
55 years and over	298	40.7	257 (86.2)	41 (13.8)	
Gender ($n = 732$, missing = 13) *Chi square value = 13.03, df = 1*					
Female	492	67.2	424 (86.2)	68 (13.8)	**< 0.001**
Male	240	32.8	181 (75.4)	59 (24.6)	
Place of birth ($n = 744$, missing = 1) *Chi square value = 0.83, df = 1*					
Australian born	618	83.1	509 (82.4)	109 (17.6)	0.362
Overseas born	126	16.9	108 (85.7)	18 (14.3)	
Aboriginal and Torres Strait Islander status ($n = 730$, missing = 15) *Chi square value = 27.94, df = 1*					
Aboriginal and Torres Strait Islander	25	3.4	11 (44.0)	14 (56.0)	**< 0.001**
Non Indigenous	705	96.6	595 (84.4)	110 (15.6)	
Relationship status ($n = 729$, missing = 16) *Chi square value = 30.45, df = 1*					
Single	192	26.3	134 (69.8)	58 (30.2)	**< 0.001**
In a relationship	537	73.7	469 (87.3)	68 (12.7)	
Highest education ($n = 725$, missing = 20) *Chi square value = 9.49, df = 2*					
Year 12 or less	177	24.4	144 (81.4)	33 (18.6)	**0.009**
Diploma/Trade/Tafe	237	32.7	185 (78.1)	52 (21.9)	
University degree or higher	311	42.9	273 (87.8)	38 (12.2)	
Current work status ($n = 736$, missing = 9) *Chi square value = 47.16, df = 2*					
Not employed	100	13.6	59 (59.0)	41 (41.0)	**< 0.001**
Employed	556	75.5	477 (85.8)	79 (14.2)	
Retired	80	10.9	73 (91.3)	7 (8.8)	
Annual household income ($n = 727$, missing = 18) *Chi square value = 31.87, df = 3*					
Prefer not to disclose	110	15.1	92 (83.6)	18 (16.4)	**< 0.001**
Under $50,000	242	33.3	178 (73.6)	64 (26.4)	
$50,000 $100,000	219	30.1	192 (87.7)	27 (12.3)	
Over $100,000	156	21.5	146 (93.6)	10 (6.4)	
Housing status at the time of the flood ($n = 738$, missing = 7) *Chi square value = 15.46, df = 2*					
Renting/Other	202	27.4	150 (74.3)	52 (25.7)	**< 0.001**
Had a mortgage	316	42.8	267 (84.5)	49 (15.5)	
Owned a home outright	220	29.8	194 (88.2)	26 (11.8)	

to business owners who were unaffected. The severity of flood exposure within the business premises (measured by the level of flood waters in the business) was associated with increasing levels of probable depression. In terms of cumulative effects, business owners who were both flooded and evacuated from their business had an increased OR (OR = 2.98, CI 1.85–4.81), and there was a trend towards significance for those with only one of these exposures (OR = 1.61, CI 0.93–2.80), compared to those who had neither. Business and home cumulative effect included business flood status and home flood status, both those with one exposure (OR = 3.63 CI 2.23–5.92) and both exposures (OR = 6.47 CI 3.41–12.28) showed significantly increased ORs compared to those who had neither. Insurance dispute or rejection was one of the strongest predictors for increased probable depression (OR = 4.99, CI 2.81–8.88). If income was

Table 2 Flood exposure, financial factors and previous flood exposure- association with probable depression ($n = 745$)

	Total		Probable Depression		*P* value
			No *n = 618 (83%)*	*Yes* *n = 127 (17%)*	
	n	%	n (%)	n (%)	
2017 Flood Exposure					
Business flooded (n = 745, missing = 0) *Chi square = 19.50, df = 1*					
Not flooded	474	63.6	415 (87.6)	59 (12.4)	**< 0.001**
Flooded	271	36.4	203 (74.9)	68 (25.1)	
Evacuated business (n = 729, missing = 16) *Chi square = 16.60, df = 1*					
Did not have to evacuate	447	61.3	390 (87.2)	57 (12.8)	**< 0.001**
Had to evacuate	282	38.7	213 (75.5)	69 (24.5)	
Level of water in business (n = 738, missing = 7) *Chi square = 32.72, df = 4*					
Not flooded	474	64.2	415 (87.6)	59 (12.4)	**< 0.001**
Water in some areas but not all of the business	44	6.0	39 (88.6)	5 (11.4)	
Water below knee in entire business	24	3.3	21 (87.5)	3 (12.5)	
Water between knee and head height in entire business	120	16.3	86 (71.7)	34 (28.3)	
Water above head height in entire business	76	10.3	51 (67.1)	25 (32.9)	
Warning given by emergency services to evacuate business (hours) ($n = 209$, missing = 536) *Chi square = 0.41, df = 2*					
No warning	88	42.1	68 (77.3)	20 (22.7)	0.814
Four hours or less	81	38.8	60 (74.1)	21 (25.9)	
More than four hours	40	19.1	29 (72.5)	11 (27.5)	
Liveable area of home flooded or damaged (n = 725, missing = 20) *Chi square = 41.28, df = 1*					
No	567	78.2	499 (88.0)	68 (12.0)	**< 0.001**
Yes	158	21.8	105 (66.5)	53 (33.5)	
Home evacuation (n = 732, missing = 13) *Chi square = 52.23, df = 1*					
No	608	83.1	534 (87.8)	74 (12.2)	**< 0.001**
Yes	124	16.9	76 (61.3)	48 (38.7)	
Any length of displacement from home (n = 745, missing = 0) *Chi square = 35.66, df = 1*					
No	633	85.0	547 (86.4)	86 (13.6)	**< 0.001**
Yes	112	15.0	71 (63.4)	41 (36.6)	
Cumulative business impact (n = 729, missing = 16) *Chi square = 24.22, df = 2*					
Business neither flooded nor evacuated	379	52.0	334 (88.1)	45 (11.9)	**< 0.001**
Business flooded or evacuated	151	20.7	126 (83.4)	25 (16.6)	
Business flooded and evacuated	199	27.3	143 (71.9)	56 (28.1)	
Cumulative business and home impact (n = 725, missing = 20) *Chi square = 50.06, df = 2*					
Neither business nor home flooded	381	52.6	350 (91.9)	31 (8.1)	**< 0.001**
Business or home flooded	271	37.4	208 (76.8)	63 (23.2)	
Business and home flooded	73	10.1	46 (63.0)	27 (37.0)	
Flood Related Financial Factors					
Insurance disputes/rejections (n = 738, missing = 7) *Chi square = 66.24, df = 1*					
No	669	90.7	579 (86.5)	90 (13.5)	**< 0.001**
Yes	69	9.3	33 (47.8)	36 (52.2)	
Flood effect on income ($n = 738$, missing = 7) *Chi square = 35.73, df = 2*					
No effect	431	58.4	375 (87.0)	56 (13.0)	**< 0.001**
Income reduced after flood, but now back to normal	182	24.7	157 (86.3)	25 (13.7)	
Income remains reduced	125	16.9	81 (64.8)	44 (35.2)	

Table 2 Flood exposure, financial factors and previous flood exposure- association with probable depression (*n* = 745) *(Continued)*

	Total		Probable Depression		*P* value
			No *n = 618 (83%)*	*Yes* *n = 127 (17%)*	
	n	%	n (%)	n (%)	
Previous Flood Exposure Damage (prior to 2017)					
Previous damage to home/work due to flood (n = 738, missing = 7) *Chi square = 2.93, df = 2*					
No	284	38.5	228 (80.3)	56 (19.7)	0.231
Once twice	235	31.8	202 (86.0)	33 (14.0)	
Several times	219	29.7	182 (83.1)	37 (16.9)	
Previous exposure to Northern Rivers flood (n = 744, missing = 1) *Chi square = 0.83, df = 2*					
No	101	13.6	83 (82.2)	18 (17.8)	0.659
Once twice	238	32.0	194 (81.5)	44 (18.5)	
Several times	405	54.4	341 (84.2)	64 (15.8)	

reduced after the flood but had returned to normal within six months, the OR was not significantly different from those whose income was not affected by the flood. However, if the income had been reduced by the flood and remained reduced, there was an increased OR compared to those whose income had returned to normal (OR = 3.71, CI 2.02–6.78).

Multivariable logistic regression

For the multivariable logistic model, after adjusting for demographic and flood related factors, the OR for business evacuation remained similar to that of the univariable model AOR = 2.11, CI 1.25–3.57, compared to OR = 2.22 (Tables 5 and 6). However, the AOR for home flooding or damage, although remaining significant, reduced from

Table 3 Probable depression association and crude ORs for support factors: univariable logistic regression (*n* = 745)

	Total		Probable Depression		*P* value	Probable Depression OR(95% CI)	*P* value
			No *n = 618 (83%)*	*Yes* *n = 127 (17%)*			
	n	%	n (%)	n (%)			
Perceived Support Needs by:							
State government (*n* = 335)[a] *Chi square = 5.26, df = 1*							
Needs unmet	284	84.8	208 (73.2)	76 (26.8)	**0.022**	2.74 (1.12 6.68)	**0.027**
Needs met	51	15.2	45 (88.2)	6 (11.8)		REF	
Local council (*n* = 394)[b] *Chi square = 3.39, df = 1*							
Needs unmet	300	76.1	221 (73.7)	79 (26.3)	0.066	1.74 (0.96 3.16)	0.068
Needs met	94	23.9	78 (83.0)	16 (17.0)		REF	
Community organisations (n = 335)[c] *Chi square = 2.89, df = 1*							
Needs unmet	204	60.9	145 (71.1)	59 (28.9)	0.089	1.57 (0.93 2.64)	0.091
Needs met	131	39.1	104 (79.4)	27 (20.6)		REF	
Insurance company (*n* = 304)[d] *Chi square = 6.78, df = 1*							
Needs unmet	244	80.3	171 (70.1)	73 (29.9)	**0.009**	2.78 (1.26 6.13)	**0.012**
Needs met	60	19.7	52 (86.7)	8 (13.3)		REF	
Emergency services (*n* = 323)[e] *Chi square = 1.37, df = 1*							
Needs unmet	206	63.8	148 (71.8)	58 (28.2)	0.243	1.37 (0.81 2.33)	0.244
Needs met	117	36.2	91 (77.8)	26 (22.2)		REF	
Volunteers/Neighbours (*n* = 436)[f] *Chi square = 0.99, df = 1*							
Needs unmet	192	44.0	145 (75.5)	47 (24.5)	0.320	1.26 (0.80 1.98)	0.321
Needs met	244	56.0	194 (79.5)	50 (20.5)		REF	

REF Reference category
Missing/Don't Know/Not Applicable: [a] n = 410; [b] n = 351; [c] n = 410; [d] n = 441; [e] n = 422; [f] n = 309

Table 4 Probable depression crude ORs for demographics: univariable logistic regression ($n = 653$)

	Probable Depression OR (95% CI)	*P* value
Demographics		
Gender (missing = 0)		
Female	REF	
Male	1.88 (1.24 2.86)	**0.003**
Aboriginal and Torres Strait Islander status (missing = 0)		
Aboriginal and Torres Strait Islander	7.97 (3.44 18.47)	**< 0.001**
Non Indigenous	REF	
Relationship status (missing = 0)		
In a relationship/Married	REF	
Single/Divorced/Separated/Widowed	3.31 (2.15 5.09)	**< 0.001**
Education ($n = 644$, missing = 9)		0.069
Year 12 or less	REF	
Diploma/Trade/Tafe	1.26 (0.73 2.17)	0.406
University degree or higher	0.71 (0.41 1.23)	0.221
Current work status ($n = 646$, missing = 7)		**< 0.001**
Not employed	4.15 (2.48 6.95)	**< 0.001**
Employed	REF	
Retired	0.57 (0.24 1.37)	0.210
Annual household income (missing = 0)		**< 0.001**
Prefer not to disclose	2.76 (1.14 6.66)	**0.024**
Under $50,000	6.37 (3.05 13.31)	**< 0.001**
$50,000 $100,000	2.20 (0.99 4.89)	0.052
Over $100,000	REF	
Housing status at the time of the flood (missing = 0)		**< 0.001**
Renting/Other	3.03 (1.71 5.38)	**< 0.001**
Had a mortgage	1.49 (0.85 2.62)	0.168
Owned a home outright	REF	

REF Reference category

OR = 3.87 to AOR = 2.14, CI 1.25–3.66, compared to those who were not affected. Insurance disputes/rejections remained one of the strongest predictors for probable depression (AOR = 3.76, CI 1.86–7.60, down from OR = 4.99). Prolonged reduction in income also had a significantly increased AOR 2.53 (1.26–5.07). In summary, flood exposure and financial factors were associated with probable depression after adjustment for relevant demographic variables.

Discussion

Our results identified multiple factors that influenced the likelihood of probable depression amongst business owners post-flooding. Key findings were that those who had their business flooded or evacuated, those who had insurance disputes/rejections or those whose income was persistently reduced six months post-flood had an increased risk for probable depression. The majority of business owners felt their needs were not met by most organisations providing flood-related support. We identified that in our sample 25.1% of business owners whose businesses were flooded reported probable depression, compared to 12.4% of those whose businesses were not flooded. This compares to the Australian national 12 month prevalence of depression of 4.1% [16]. Rates of depression post flooding vary greatly between studies, but have been as high as 35.1% in affected populations [5].

Business flooding and the impact on income

Business flood exposure put business owners at an increased risk of probable depression and this was markedly higher with increasing depths of water inundation. Similarly, a Thai study reported that those who suffered a loss of business as a result of the 2004 tsunami had poorer overall mental health scores one-year post-tsunami [9]. This may be explained by the direct and indirect economic impacts that contribute to

Table 5 Probable depression crude ORs for flood exposure and financial factors: univariable logistic regression ($n = 653$)

	Probable Depression OR (95% CI)	*P* value
2017 Flood Exposure		
Business flooded (missing = 0)		
Not flooded	REF	
Flooded	2.39 (1.57 3.63)	**< 0.001**
Evacuated business (missing = 0)		
No	REF	
Yes	2.22 (1.46 3.37)	**< 0.001**
Degree of flooding to business (n = 646, missing = 7)		**< 0.001**
Not flooded	REF	
Water in some areas but not all	0.61 (0.18 2.06)	0.428
Water below knee in entire business	0.73 (0.17 3.24)	0.638
Water between knee and head height in entire business	2.90 (1.71 4.91)	**< 0.001**
Water above head height in entire business	3.92 (2.20 6.97)	**< 0.001**
Liveable area of home flooded or damaged (missing = 0)		
No	REF	
Yes	3.87 (2.47 6.05)	**< 0.001**
Home evacuation ($n = 649$, missing = 4)		
No	REF	
Yes	5.08 (3.15 8.20)	**< 0.001**
Any length of displacement from home (missing = 0)		
No	REF	
Yes	4.45 (2.70 7.32)	**< 0.001**
Business cumulative effect (missing = 0)		**< 0.001**
Business neither flooded nor evacuated	REF	
Business flooded or evacuated	1.61 (0.93 2.80)	0.092
Business flooded and evacuated	2.98 (1.85 4.81)	**< 0.001**
Business and home cumulative effect (missing = 0)		**< 0.001**
Neither business nor home flooded	REF	
Business or home flooded	3.63 (2.23 5.92)	**< 0.001**
Business and home flooded	6.47 (3.41 12.28)	**< 0.001**
Flood Related Financial Factors		
Insurance disputes/rejections (missing = 0)		
No	REF	
Yes	4.99 (2.81 8.88)	**< 0.001**
Flood effect on income (missing = 0)		**< 0.001**
No effect	0.92 (0.54 1.59)	0.773
Income reduced after flood, but now back to normal	REF	
Income remains reduced	3.71 (2.02 6.78)	**< 0.001**

REF Reference category

economic vulnerability of small businesses post-disaster and may act as significant stressors. The economic impacts can result from physical injury, direct damage to the business premises, evacuation, associated loss of income and loss of stock/equipment and associated repairs. Indirect impacts include lack of customers and staff, issues with support post event, supply chain interruption and difficulties with transport and access [7, 17]. Furthermore, other factors that affect the broader working community may act as additional stressors for business owners. For example, as identified in a study of

Table 6 Probable depression AOR amongst business owners: multivariable logistic regression Model ($n = 653$)

	Probable Depression AOR(95% CI)	*P* value
Demographics		
Gender		
Male	2.44 (1.47 4.04)	**0.001**
Female	REF	
Aboriginal and Torres Strait Islander status		
Aboriginal and Torres Strait Islander	6.48 (2.43 17.25)	**< 0.001**
Non Indigenous	REF	
Relationship status		
In a relationship/Married	REF	
Single/Divorced/Separated/Widowed	2.22 (1.30 3.80)	**0.004**
Annual household income		**0.013**
Prefer not to disclose	1.66 (0.62 4.47)	0.318
Under $50,000	3.42 (1.47 7.98)	**0.004**
$50,000 $100,000	1.71 (0.73 3.99)	0.218
Over $100,000	REF	
Housing status at the time of the flood		**0.013**
Renting/Other	2.73 (1.40 5.33)	**0.003**
Had a mortgage	1.89 (0.97 3.70)	0.062
Owned a home outright	REF	
2017 Flood Exposure		
Had to evacuate business		
No	REF	
Yes	2.11 (1.25 3.57)	**0.005**
At least one liveable area of home flooded or damaged		
No	REF	
Yes	2.14 (1.25 3.66)	**0.006**
Flood related Financial Factors		
Insurance disputes/rejections		
No	REF	
Yes	3.76 (1.86 7.60)	**< 0.001**
Flood effect on income		**0.030**
No effect	1.41 (0.75 2.68)	0.289
Income reduced after flood, but now back to normal	REF	
Income reduced after flood and remains reduced	2.53 (1.26 5.07)	**0.009**

REF Reference Category
Nagelkerke R square = 0.329

American university students, flood-related work disruption resulted in poorer self-reported mental health status. Factors that influence this may include communication difficulties between employees and employers, lack of access to social support at work, uncertainty regarding flood-related work expectations and difficulty travelling to work [18]. A 2019 Bangladeshi study found that being younger, earning an income, having physical injuries due to a disaster, and post-disaster work absenteeism were risk factors of depression post-cyclone Mora [19]. Unemployment and job insecurity, independent of a natural disaster, have also been repeatedly shown to be associated with depression all around the world [19, 20]. It has also been found that unemployment remains a significant risk factor for depression independent of other contributing factors such as social support, financial stress and a sense of personal control [20].

Our study found that persistent reduction in income due to the floods was a significant risk factor for

probable depression (AOR = 2.53, 1.26–5.07). Whereas, initial reduction in income that had returned to normal within six months had no effect on probable depression. In the general population, an association between financial losses and poor mental health outcomes has been established, [2] however ongoing economic recovery may be more complex for business owners due to additional financial stressors. Unlike our results, a Sri Lankan study following the 2004 tsunami, found little association between economic recovery and mental health recovery for affected business owners. However, as discussed earlier, it is difficult to directly compare this study with ours [8].

Our findings provide evidence that supporting businesses after the disaster and assisting the local economy in its recovery could help to reduce the mental health burden on the business community, which may in turn help the broader community. Indeed, post-flood, a chaplaincy program was implemented by the local government in the Lismore area to assist business owners with emotional and psychological support. This program was largely well received by business owners, and is credited to have both provided psychological support, as well as raise mental health awareness in the community [21]. Furthermore, addressing economic vulnerability of business owners prior to a flood in disaster prone areas may assist in preventing adverse consequences.

Business evacuation and evacuation warning time

Business evacuation was significantly associated with probable depression. Home evacuation has been found to be associated with poorer mental health in previous research, however this has not yet been shown in business evacuation [2, 22]. We found that business evacuation warning time was not significantly related to probable depression. The research surrounding this topic is somewhat conflicting. A 2007 English study found that the economic benefit of flood warnings is low for households because portable items consist of a low proportion of overall household property [23]. This may not be the case for business owners, especially in industries with large amounts of moveable stock. The aforementioned study also found that simply receiving a warning did not improve mental health outcomes, but if those who did not receive a warning were excluded, there was a small benefit to longer warning times [23]. Our study was not consistent with these findings. Further research may be necessary to determine the entire scope of benefits of early evacuation warnings, including physical and mental health and economic preparedness for business owners.

Insurance

Insurance disputes and rejections (including home, business or other property/possessions) affected 9.3% of all business owners who thought they were fully insured and was one of the strongest associations with probable depression. Insurance problems post-flooding has been repeatedly shown to result in poorer mental health in the general population [2, 22, 24, 25]. Business owners may be particularly vulnerable to insurance disputes because it can limit their access to capital necessary to reopen their business and thereby contribute to long-term loss of income.

A 2018 study found that 56% of businesses in one area of our study region did not have flood insurance and 31% were unsure if they had flood insurance [26]. Exorbitant cost has been identified as a perceived barrier to flood insurance by business owners [11, 26]. There is significant capacity for improvement in the insurance process including affordability, speed and ease of claiming, being transparent regarding inclusions and exclusions, and improving communication [11].. Such changes may have a positive impact on business owner's mental health in the event of future flooding.

Prior flood exposure

Prior flood exposure was not significantly associated with probable depression in our study. However, in the general population, there is some evidence to suggest that prior flood exposure may increase the risk of mental health problems including depression [5, 27]. This may be explained by the cumulative effect of repeated flood exposure particularly in vulnerable groups and fear of future flooding based on prior negative experiences [5].

We postulate that prior flood exposure may be a complex factor for business owners as prior flood exposure has been shown to improve flood preparedness. Therefore, flood preparedness may improve the economic and mental health outcomes for business owners [28]. These two conflicting factors, repeated trauma and flood preparedness, may be contributing to the lack of significance of prior flood exposure in our study. Further research in this area is warranted based on the conflicting results with prior literature.

Satisfaction with support services post-flood

Probable depression was more prevalent in those who felt their flood-related support needs were unmet. However, this was not found to be statistically significant for most organisations, after adjusting for other factors, with the exception of insurance companies. Business owners were most likely to have felt that their needs were met by volunteers and neighbours. This finding encourages support of volunteers in both the pre- and post-event response. Aside from volunteers and neighbours, less than 50% of respondents were satisfied with the flood response of any service/organisation. This suggests that significant improvement is required by these organisations to increase satisfaction of the affected population. It is common for people to feel isolated from authorities after a flood, [24] and flood victims are more likely to come forward to trusted members of the community rather than mental health professionals [2] This should be used guide the

implementation of post-flood programs, such as was seen with the church sponsored Lismore Chaplaincy program.

Cumulative flood exposure

The negative impact of flooding, evacuation and displacement from home is well established in the literature and our findings were in concordance with this [2, 5, 22, 24]. We derived two innovative cumulative indices. The business cumulative effect index looked at business flooding in combination with business evacuation. The business and home cumulative variable combined business and home flood status. Both were associated with higher rates of probable depression amongst business owners. Our findings demonstrate that those with compounding exposures are particularly vulnerable and should be identified as a target for mental health and economic support.

Demographic factors

Predictive demographic factors of probable depression included male gender, Aboriginal or Torres Strait Islander, being single, low household income and renting at the time of the flood. Without knowledge of pre-existing depression rates it is difficult to assess these factors in a cross-sectional study. However, low income and renting have previously been associated with increased mental health vulnerability post-flooding [22]. Financial pressure pre-disaster may mean a business owner was particularly impacted by an interruption to income and the associated stressors of flooding.

Our study identified that male business owners had twice the AOR of probable depression compared to females. Prior research has found either no association with gender or that females have poorer mental health outcomes after flooding [2, 22]. This requires further investigation.

The highest AOR (6.48) for probable depression was in the Aboriginal and Torres Strait Islander population, however the sample size was small ($n = 24$). In general, the Aboriginal and Torres Strait Islander population have an increased mental health disease burden a result of continuing discrimination, social and economic inequality stemming from colonisation and disempowerment, [29] and may be particularly susceptible to external stressors such as flooding.

Disaster preparedness

A crisis management framework consisting of disaster prevention, response and recovery, [7] can contribute to minimising the impact of flooding events on business owners. Given the link we have established between economic recovery and mental health recovery, flood preparedness is paramount in minimising the initial impacts on business owners. Individual prevention measures may include disaster plans and flood insurance. On a broader scale, flood infrastructure, such as levees, can also assist in mitigating the impact of floods. For example, a levee was recently built in the study region, prior to the March 2017 flood. However, it is proposed that the relatively new levee provided a false sense of security amongst the local business community, especially amongst those without prior flood experience, and it took many by surprise when it overflowed [26]. It has been suggested that further flood education by the local government may have prevented the lack of preparedness in the study community [11, 26]. In summary, individual disaster plans in conjunction with system level changes such as infrastructure and education are vital for disaster preparedness.

Limitations

One limitation of this study is that the sample is not representative of the general population [13]. Self-selection bias would inevitably have favoured those who had been affected by the flooding. Furthermore, the survey relied on self-reported data which may affect the accuracy of the information. However, the survey used validated instruments wherever possible (including the PHQ-2 for probable depression) and the methods were in line with previous literature [2, 22]. Although, PHQ-2 is a brief, well-known and validated tool, the longer versions may have increased the accuracy of measuring depressive symptoms. However, the authors chose the shortest measure to enable higher response and completion rates and thus have more meaningful data, and took into account survey length, the inconvenience and potential aversion towards survey completion and survey fatigue.

Secondly, business owners self-identified and the survey did not include the industry groups, therefore we cannot provide a distribution within the business owner sample. Furthermore, business owners may also have been affected by the flood in other areas of their life, such as their home and loved ones. This is difficult to separate and may have an impact on the outcome results. For this reason, home flooding status was adjusted for in the final model. Lastly, given that the pre-flood prevalence of probable depression amongst our population group is not known, we instead compared exposed business owners to non-exposed business owners.

Conclusion

The association of probable depression with flood exposure and flood-related financial factors was highly significant amongst business owners. Business flooding, evacuation, high levels of water inundation, insurance disputes and persistent reduction in income, were all important predictive factors. Cumulative impacts of both business and home factors also proved to be significant. These findings highlight the vulnerability of exposed business owners and the need for more effective support. The poor satisfaction of business owners with flood-related services confirms the need for improvement. Improvements may include individual disaster planning programs in conjunction with system level changes such as infrastructure and education which are vital for disaster preparedness.

Appendix 1

Table 7 Chi-Square analysis of collinear variables

Variable Included in the Model	Variable Excluded from the Model	Chi Square	
		df	*p* value
Annual household income	Current work status	6	**< 0.001**
Business evacuation	Business flooded	1	**< 0.001**
Business evacuation	Level of water in business	5	**< 0.001**
Liveable area of home flooded	Home evacuation	1	**< 0.001**
Liveable area of home flooded	Displaced from home	1	**< 0.001**
Believed they were fully insured but the insurance company rejected or disputed their claim	Insurance company support needs	1	**< 0.001**

Appendix 2

Table 8 Probable depression AOR amongst business owners: multivariable logistic regression model including cumulative business exposure ($n = 653$)

	Probable Depression AOR(95% CI)	*P* value
Demographics		
Gender		
Male	2.34 (1.41 3.89)	**0.001**
Female	REF	
Aboriginal and Torres Strait Islander status		
Aboriginal and Torres Strait Islander	6.40 (2.39 17.11)	**< 0.001**
Non Indigenous	REF	
Relationship status		
In a relationship/Married	REF	
Single/Divorced/ Separated/Widowed	2.24 (1.31 3.84)	**0.003**
Annual household Income		**0.012**
Prefer not to disclose	1.56 (0.58 4.19)	0.380
Under $50,000	3.38 (1.46 7.86)	**0.005**
$50,000 $100,000	1.68 (0.72 3.93)	0.230
Over $100,000	REF	
Housing status at the time of the flood		**0.008**
Renting/Other	2.89 (1.47 5.65)	**0.002**
Had a mortgage	1.90 (0.98 3.72)	0.059
Owned a home outright	REF	
2017 Flood Exposure		
Cumulative business exposure		**0.013**
Business neither flooded nor evacuated	REF	
Business flooded or evacuated	1.80 (0.94 3.46)	0.079
Business flooded and evacuated	2.63 (1.38 5.04)	**0.003**
At least one liveable area of home flooded or damaged		
No	REF	
Yes	2.14 (1.25 3.67)	**0.005**
Flood Related Financial Factors		
Believed they were fully insured but the insurance company rejected or disputed their claim		
No	REF	
Yes	3.50 (1.73 7.10)	**0.001**
Flood effect on income		**0.044**
No effect	1.58 (0.82 3.06)	0.171
Income reduced after flood, but now back to normal	REF	
Income reduced after flood and remains reduced	2.43 (1.21 4.88)	**0.013**

REF Reference Category
Nagelkerke R square = 0.331

Abbreviations

PTSD: Post Traumatic Stress Disorder; NSW: New South Wales; PHQ 2: Patient Health Questionnaire; OR: Odds Ratio; AOR: Adjusted Odds Ratio; CI: 95% Confidence Interval; REF: Reference category

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Authors' contributions

All authors contributed to the study design. KF performed the data analysis and drafted the manuscript. KF, SWP, MR, JM interpreted the data. All authors critically reviewed draft versions and provided important intellectual content during revisions. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets supporting the conclusions of this article are not available form the corresponding author due to the sensitive nature of the data and the consent being provided for participation in the specific study.

Ethics approval and consent to participate

Ethics approval was granted by University of Sydney Human Research Ethics Committee and Aboriginal Health and Medical Research Council Human Research Ethics Committee (Ethics ID 2017/589 and 1294/17 respectively). Completion of survey was taken as consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Insurance Issues as Secondary Stressors Following Flooding in Rural Australia—A Mixed Methods Study

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Abstract: Flood events can be dramatic and traumatic. People exposed to floods are liable to suffer from a variety of adverse mental health outcomes. The adverse effects of stressors during the recovery process (secondary stressors) can sometimes be just as severe as the initial trauma. Six months after extensive flooding in rural Australia, a survey of 2530 locals was conducted focusing on their flood experiences and mental health status. This mixed methods study analysed (a) quantitative data from 521 respondents (21% of total survey respondents) who had insurance coverage and whose household was inundated, 96 (18%) of whom reported an insurance dispute or denial; and (b) qualitative data on insurance-related topics in the survey's open comments sections. The mental health outcomes were all significantly associated with the degree of flood inundation. The association was strong for probable PTSD and ongoing distress (Adjusted Odds Ratios (AORs) with 95% confidence intervals 2.67 (1.8–4.0) and 2.30 (1.6–3.3), respectively). The associations were less strong but still significant for anxiety and depression (AORs 1.79 (1.2–2.7) and 1.84 (1.2–2.9)). The secondary stressor of insurance dispute had stronger associations with ongoing distress and depression than the initial flood exposure (AORs 2.43 (1.5–3.9) and 2.34 (1.4–3.9), respectively). Insurance was frequently mentioned in the open comment sections of the survey. Most comments (78% of comments from all survey respondents) were negative, with common adverse trends including dispute/denial, large premium increases after a claim, inconsistencies in companies' responses and delayed assessments preventing timely remediation.

Keywords: disaster recovery; secondary stressors; insurance dispute; mental health; flood; mixed methods

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1. Introduction

One of the many consequences of global warming is a dramatic increase in the frequency and severity of extreme weather events, including flooding [1]. Being flooded at home can be a traumatic experience; physical injury, destruction of property, dislocation and severe disruption are all common consequences. Understanding the impact of flooding events and implications for the recovery process is increasingly important.

The effects of flooding on mental health are no less important than the immediately obvious physical consequences. For example, in the UK, adverse mental health outcomes have been shown to account for 80% of all Disability Adjusted Life Years attributable to floods [2]. Adverse mental health outcomes associated with floods include PTSD, anxiety, distress and depression [3,4].

1.1. Secondary Stressors and Mental Health

After disasters such as flooding, restoration of the built environment, finances and social cohesion can take considerable time and effort. During this time, flood-affected people are especially vulnerable to "secondary stressors" [5,6].

We refer to the immediate and direct adverse effects of disasters such as flooding as primary stressors. The definition of secondary stressors in the research literature has not always been clear or consistent [7]. For the purposes of this paper, we consider secondary stressors to be indirect consequences of a traumatic event (such as flooding) that are ongoing, unresolved obstacles to a return to what is perceived as normality [4,7,8]. Secondary stressors can occur in the immediate aftermath of the event and persist for months or years afterwards [9–11]. Secondary stressors can include delays and disputes when dealing with insurance and construction companies, problems with personal relationships, loss of employment and financial hardship [12]. They are associated with poor mental health outcomes [6,12] and a loss of confidence in services and authorities [3,13]. Secondary stressors can have even greater mental health impacts than the original disaster, according to both quantitative studies [14] as well as self-reported by victims [15].

Since secondary stressors are ongoing, unresolved obstacles to recovery, their mental health effects may be different in nature to those from the dramatic, short-term impact of the original disaster [6,8]. People's patterns of vulnerability can also change through the disaster and recovery phases [16,17]. This complexity implies that no one measure will provide an adequate depiction of flood-affected people's mental health. Most disaster studies focus on PTSD as the key mental health outcome measure [9], while depression, distress and anxiety are less frequently studied in the literature.

The current study covers a suite of mental health measures; anxiety, depression, flood-related probable PTSD and ongoing flood-related distress. The mental health effects of flooding severity and insurance dispute (the primary and secondary stressors) are modelled.

Insurance dispute is frequently cited as a particularly significant source of secondary stress [3,7,8,18] and its impact can be severe [11,19]. Common complaints include delays in dealing with claims, the attitude of insurance staff, unreasonable denial or reduction in claims, inconsistent decision making and the stressful claims process [3,8,16,19]. In Australia, many insurers use preferred repairers and suppliers and organize and pay for that directly. Other insurers make a payout to the insured person to fund repairs and goods lost or damaged. In the case of extreme-weather-related events, insurance companies may appoint a loss assessor which can add to delays, particularly when many properties are damaged and there are many claims being processed simultaneously [20].

1.2. Flooding in the Northern Rivers Region

The Northern Rivers region of northern NSW, Australia, has a resident population of around 240,000 [21]. The main economic drivers include tourism, retail, human services, horticulture and agriculture [22]. The region includes many areas of relative socioeconomic disadvantage [22,23] and has higher proportions of older people, low-income individuals and people with limited education compared to state and national averages [22,23].

The region is a known hotspot for weather-related extreme events, particularly flooding [23,24]. In early 2017, extreme rainfall from ex-Tropical Cyclone Debbie flooded many regions of the Northern Rivers including the major population centres of Lismore and Murwillumbah. There was extensive damage to housing and infrastructure and major disruption of the affected population.

The current work analyses survey responses collected six months after the devastating flood of 2017. We used a mixed methods approach to investigate insurance issues, including disputes, as secondary stressors.

We analyse the extent to which the primary and secondary stressors impact a variety of mental health measures.

We also report a qualitative analysis of how participants' experiences with insurance acted as a secondary stressor and how this influenced community perceptions of insurance.

2. Methods

2.1. The Community Recovery after Flood Survey

Six months after the 2017 floods, the University Centre for Rural Health (UCRH, the University of Sydney, Australia) undertook a cross-sectional survey exploring participants' experience of the flood and their mental health outcomes. The research approach was based on strong community–academic partnerships, purposively surveying a broad cross-section of the community, with recruitment strategies which leveraged these community partnerships supplemented by local media advertising, posters and flyers and an extensive social media strategy. Recruitment focused on hard-to-reach population groups and groups known to be particularly at risk of the effects of extreme-weather-related events, including young people (16–25), older people (75 years and over), those socioeconomically disadvantaged, those identifying as Aboriginal and/or Torres Strait Islander, farmers and business owners. The study did not, therefore, recruit a random and representative sample, as its aim was to describe the associations of exposure to the flood and mental health outcomes rather than to assess prevalence of either flood exposure or outcomes [25].

The survey was made available online, mobile phone and in paper form from September to November 2017 to people aged 16 and over, living in the Northern Rivers at the time of the flood. The questionnaire included a variety of exposure measures, such as inundation of home, evacuation and impact on respondents' neighbourhood and family.

Three specific questions about insurance were included (see Appendix A for the relevant survey questions):

- Whether respondents felt that they got the support they needed from their insurance company (with an N/A response taken to mean the respondent had no insurance or no need to claim);
- Whether they believed that they were fully insured but the insurance company rejected or disputed their claim;
- Whether insurance companies were to blame for anyone's distress after the flood.

There were also eight opportunities for open comment (free text).

2.2. Quantitative Methods

A total of 2530 surveys were returned.

The quantitative study cohort consisted of all survey respondents who:

- Reported being flooded in their household (1215 retained);
- Gave an answer other than N/A in the insurance support question, indicating that they had dealings with an insurance company after the flood (697 retained);
- Did not select "Other" for housing type (response options were Rent, Mortgage, Own and Other) (629 retained);
- Had complete data for the demographic variables considered (572 retained) and exposure measures (549 retained);
- Answered all questions used in the analysis for the PTSD and "still distressed" mental health outcomes (521 retained).

Respondents who selected "Other" for housing type were excluded from further analyses because the free text showed they were too diverse to be meaningfully analysed: responses included "staying with family", "in a retirement home" and "homeless".

We used anxiety (GAD-2) and depression (PHQ-2), as well as two flood-specific mental health measures "probable PTSD" (PCL-6) and "still distressed" as dichotomous mental health and wellbeing outcome measures. Previously published papers have further details on these measures [25] and their prevalence amongst the survey respondents [26].

Our key secondary stressor exposure was "insurance rejected or disputed" (dispute).

We used self-reported "flooded inside the living area of their house" as a dichotomous degree of inundation variable. (Everyone in the study cohort reported a degree of inundation: in the living and/or non-living areas of their household.)

Consistent with the English National Study of Flooding and Health [18], we developed logistic regression models for the mental health outcomes. We regarded the primary and secondary stressors (degree of inundation and insurance dispute) as the primary predictors and adjusted for demographics (employment status, relationship status and housing type). These were selected from a broader suite of demographic factors (including age and gender) after a process of stepwise regression.

2.3. Qualitative Methods

The free text responses from all 2530 completed surveys were analysed. Using a qualitative descriptive approach [27], qualitative data from the eight free text opportunities in the survey were deductively coded using a realist content analysis following the steps outlined by Elo and Kynga [28]. An initial structured coding index was generated based on the wider literature on mental health and floods [3,5,18], the interests of the community which were established through our community–academic partnership and the aims of this paper. Two authors (J.L. and M.B.) trialed the index by independently coding a sample of comments from participants that were particularly extensive and detailed, and the coding index was refined following discussion and agreement between J.L. and M.B. This process was repeated with a further sample of comments and coding (independently by J.L. and M.B.) was tested for concordance in NVivo 11, showing a high level of concordance. J.L., M.B. and J.M. then used the final index to code all the data. Once the data were coded, the codes were grouped together into categories and the interpretation developed by J.L. and M.B. as described below along with the selection of illustrative quotes from the raw data.

3. Results

3.1. The Quantitative Study Cohort

A total of 2530 surveys were returned. A separate sub-study in which we door-knocked in flood-affected and non-flood-affected areas showed that around 5% of the population in both the flooded areas and those outside had completed the survey [25].

Of 2530 questionnaires returned, 1215 respondents reported that they were flooded in their household. Of these, 518 were excluded from further analysis because they responded that insurance support was not applicable, leaving 697 candidate surveys. The final quantitative cohort was comprised of the 521 surveys that had sufficiently complete demographic, primary mental health outcomes (PTSD and ongoing distress) and exposure data.

Table 1 below provides summary information about this cohort. They broadly resemble the total sample of 2530 respondents although certain groups of respondents are somewhat under-represented in the final study cohort: for example, being in a relationship (63.5% in the study cohort compared to 67.7% of all surveys) and employed (63.5% compared to 68.6%). This is consistent with the finding that respondents with various risk factors, including low socioeconomic status, were especially impacted by the 2017 floods [23]. House insurance is compulsory for mortgagees, who are therefore also over-represented, comprising 37.0% of inundated households and 44.9% of the study cohort. The demographic profiles of the survey respondents are presented in more detail in a previous paper [25].

Table 1. Demographics of the quantitative study cohort (n = 521) and all surveys that completed the item.

		Quant Cohort	All Surveys
Variable	**Value**	**Number (%)**	
Age	Under 30	32 (6.1)	197 (8.4)
	31–64	401 (77.9)	1711 (72.8)
	Over 64	88 (16.9)	442 (18.8)
Gender	Female	363 (69.7)	1617 (68.4)
Employed	Yes	335 (63.5)	1612 (68.6)
In Relationship	Yes	331 (63.5)	1581 (67.7)
Housing Status	Renting	117 (22.5)	596 (26.5)
	Mortgage	234 (44.9)	888 (39.4)
	Owner	170 (32.6)	767(34.1)

3.2. Quantitative Results

Table 2 below lists the prevalence of various exposures and mental health outcomes amongst the 521 quantitative cohort members. A total of 96 respondents from the study cohort reported insurance denial, 159 had probable PTSD and 224 reported ongoing distress from the floods. We used "flooded inside house" in our regression models as the measure of severity of flooding.

Table 2. Prevalence of exposures and mental health and wellbeing outcomes.

Variable	**Number (%)**
Exposures:	
Insurance Dispute	96 (18.4)
Flooded Inside	279 (53.6)
Mental Health:	
Probable PTSD	159 (30.5)
Anxiety [1]	142 (27.7)
Depression [1]	134 (26.1)
Still Distressed	224 (43.0)

[1] The anxiety and depression measures have some missing values (9 and 8, respectively).

The logistic regression results adjusted for the retained demographic factors are in Table 3.

Table 3. Adjusted regression results.

	Condition			
	PTSD	**Anxiety**	**Depression**	**Still Distressed**
Co-Variate	**Adjusted Odds Ratios (95% CI)**			
Insurance Dispute	1.40 (0.86–2.3)	1.82 * (1.1–3.0)	2.49 ** (1.5–4.1)	2.33 *** (1.5–3.7)
Flooded in House	2.67 *** (1.8–4.0)	1.79 ** (1.2–2.7)	1.80 ** (1.2–2.8)	2.30 *** (1.6–3.3)
Unemployed	1.73 * (1.1–2.7)	2.12 *** (1.4–3.3)	1.82 ** (1.2–2.9)	1.47 (0.98–2.2)
Not in a relationship	1.45 (0.96–2.2)	1.04 (0.67–1.6)	1.91 ** (1.2–3.0)	0.35 (0.82–2.2)
Housing Status: Renting [1]	1.76 *	2.27 **	1.45	1.35

	(1.0–3.0)	(1.3–3.9)	(0.83–2.5)	(0.82–2.2)
Mortgage [1]	1.33	1.28	0.868	1.36
	(0.82–2.2)	(0.77–2.1)	(0.52–1.5)	(0.87–2.1)
Adjusted R^2	0.076	0.070	0.106	0.071

Significance levels: * 5%, ** 1%, *** 0.1%. [1] Compared to homeowners.

The degree of inundation was significantly associated with each mental health outcome, strongly so for PTSD (AOR 2.67 (1.8–4.0)) and ongoing distress (AOR 2.30 (1.6–3.3)).

The association between insurance dispute and ongoing distress was very strong (AOR 2.33 (1.5–3.7), as was the association between insurance dispute and probable depression (AOR 2.49 (1.5–4.1)). Dispute was also significantly associated with anxiety (AOR 1.82 (1.1–3.0)) but not with PTSD (AOR 1.40 (0.86–2.3)). It is striking that the associations of dispute with ongoing distress and depression were as strong or even stronger than their associations with the flood exposure measure.

As expected, some demographics appear to be risk factors. Being unemployed was strongly associated with higher rates of anxiety (AOR 2.12 (1.4–3.3)) and depression (AOR 1.82 (1.2–2.9)), while not being in a relationship was associated with higher rates of depression (AOR 1.91 (1.2–3.0)). Gender and age factors were not significant and were eliminated during the stepwise regression process.

3.3. Qualitative Results

This section analyses free text comments about insurance from all 2530 surveys that were returned.

3.3.1. Context for the Qualitative Results

Amongst the 2468 (95.8%) survey respondents who answered the question, 166 (6.7%) "believed that they were fully insured but the insurance company rejected or disputed their claim". Of respondents who answered, 49% believed insurance companies were "a lot" or "entirely" to blame for anyone's distress after the flood, while 49% of those with insurance reported that they did not get the support they needed from their insurance company.

Of eight free text opportunities, 2114 respondents (84%) wrote in at least one. Insurance was raised by 14.8% of respondents (381 comments from 312 respondents). This compares with, for example, the topic of disaster relief measures which received 198 comments. A majority (78%) of the comments about insurance were negative. This was the case even when the respondent had not had an insurance dispute themselves. Respondents also described how problems with insurance companies linked to other secondary stressors such as financial stress, loss of local businesses, breakdowns in relationships and decreases in the value of "home".

The 521 respondents in the quantitative cohort made similar comments but were more negative: of 251 who entered free text, 61 included insurance comments and all but 3 were negative.

Respondents described several issues with insurance companies and how these impacted their mental health.

3.3.2. Access to Insurance and Clarity of What Was Covered

Respondents commonly reported difficulties with access including availability, affordability and a lack of clarity in insurance companies' communications leading to uncertainty about what was covered by their insurance. At the heart of these comments was a reported lack of clarity around how the "event" was labelled and associated disparities within and between insurance companies about if and how they provided support following the flood, i.e., some insurers labelled the event as a "flood" and would not therefore support claims for water damage unless respondents had "floods" included as part

of their insurance policy, whereas others labelled it as "storm" and therefore supported claims for damage even when flood insurance was not part of the insurance policy.

> "Govt declared the damage to be storm-related, not a flood, yet my [insurance company] refused to help. I was not insured for flood cover as it was too expensive." (No. 1100, disputed)

Respondents described how this linked to negative mental health effects, for example:

> "It has been very demoralising watching all other homes in the street being repaired by their insurance companies for storm damage, whilst we live in our flood damaged home, with no floor covering, cut out walls, kitchen, laundry and bathroom all in need of repairs" (No. 909, disputed)

3.3.3. Claims Handling and Dispute Resolution—Customer Care

Some respondents described the poor attitude of insurance company staff, which had the potential to negatively impact on mental health. For example:

> "Insurance companies appear to have the attitude that you as a claimant are somehow to blame for the problem … If you don't know the right question then you never get a satisfactory answer. And once again it's your fault. I had a very nasty experience when a staff person from the assessor company told me to go and buy a lottery ticket." (No. 1932, not disputed)

Respondents who had not necessarily experienced an insurance dispute themselves described the poor behaviour of some insurance companies using emotive language, suggesting distress experienced vicariously in the community rather than grounded in personal experience. For example:

> "…the impact from the lack of empathy and response from companies such as [insurance company] is disgusting, the way they have treated their customers and elderly who have no way of defending themselves is despicable." (No. 1176, not disputed)

Respondents who had had to deal with insurance companies reported some difficulties with effective communication, including: companies being unresponsive and/or unreliable in their communications; having to tell their "story", being asked for new requirements or being told different answers each time they contacted the insurance company; and how stressful they found it liaising with insurance companies and/or practical issues with communicating (such as a hearing impairment), in particular linked to vulnerabilities such as pre-existing anxiety or living with a physical disability. Such difficulties were linked by respondents to exacerbations of existing or new mental health issues.

> "My husband has dementia he's 71. My mother is 89 and has mobility problems. I'm hearing impaired. Dealing with insurance claims … was extremely difficult … I was frustrated by people who don't return calls/messages, say they would come and didn't or often didn't feel validated (others worse off etc). I now suffer anxiety." (No. 1677, not disputed)

Respondents suggested that assistance with communicating with insurance companies would be welcomed both in terms of general communication and in dispute situations, for example:

> "It would be fantastic if there was someone able to help you clearly assess monetary values of losses and/or be there beside you in conversations with the insurance companies as you negotiate your way through the process." (No. 94, not disputed) and
>
> "I wasn't covered for flood, however in my opinion it was initially caused by a storm, my claim was rejected and I didn't have the energy, as I get very anxious dealing with things like this, and it all became too daunting to deal with on my

> own. I would have liked someone to really help me fight the claim!!" (No. 1377, disputed)

3.3.4. Claims Handling and Dispute Resolution—Delays

Respondents commonly reported significant delays in claims handling. These delays occurred at multiple points.

Firstly, there were delays prior to assessment of a claim when respondents were waiting for assessors to inspect their property (photographic evidence was often deemed insufficient) and expected to leave the damage and live/work around it somehow, for example for "… several weeks after the event" (No. 1698, not disputed). Respondents expressed distress about the additional damage, both physical and emotional, caused due to these delays. Some respondents, for example, found themselves living in insanitary conditions with mould. In terms of their mental health, delays meant living in a state of "limbo", unable to get on with their lives or recover.

Secondly, respondents reported delays before a decision was made by insurance companies about a payout.

> "… applications were lost, delaying any help for many weeks. This was a greater mental stress than the physical clean up" (No. 1880, disputed).

A third point of delay was once a decision was made, in actually paying out, and finally, in organising repairs.

> "The Insurance company took 6 months to repair and caused more pain and stress" (No. 1479, not disputed).

3.3.5. Links between Insurance Problems and Other Secondary Stressors

Respondents linked problems with insurance companies to other secondary stressors such as financial stress, loss of local businesses, breakdowns in relationships and decreases in the value of "home" (both fiscally and emotionally/psychologically) and community.

> "The inequity in the insurance companies' treatment of victims has led to a lot of unrest in the community and bad feelings still exist between neighbours. The social effects on the population of our small village will be felt for a long time to come." (No. 175, not disputed)

4. Discussion

The quantitative and qualitative data from the present study clearly demonstrate that adverse experiences with insurance companies at a time of particular and intense vulnerability can act as a substantial secondary stressor.

We found especially strong associations between the secondary stressor (insurance dispute) and both depression and ongoing distress, while the primary stressor (degree of inundation) was more strongly associated with probable PTSD.

Other studies have reported the negative mental health impacts of insurance disputes after flooding events. In particular, the UK National cohort study [4,10,18] investigated the effects of flooding on a variety of mental health outcomes. Mulchandarni et al. [18] specifically studied the effect of insurance as a secondary stressor using data from a survey 2 years after flooding. Of their three outcome measures (depression, anxiety and PTSD), only PTSD was significantly associated with insurance dispute (AOR 2.54 (1.1–5.9)), and their associations with severe insurance stress were marginally significant (AORs 11.08 (1.11–110.3), 4.48 (1.0–19.7) and 7.95 (2.1–30.1), respectively; see [18] Table 3).

The qualitative data support the quantitative data in linking insurance disputes with negative mental health outcomes and impeded recovery. Reported difficulties included affordability, failure to compensate, lack of clarity and consistency in insurance policies and customer care including claim handling, dispute resolution and delays. Some

respondents noted explicit links with other secondary stressors including financial stress and relationship breakdowns. Adverse opinions of the insurance industry were frequently reported by respondents on the basis of others' experiences; these opinions were only weakly reflected in the quantitative data on insurance dispute.

These findings have implications for clinical practice, recovery support and conceptual understanding. The highly significant association between insurance dispute and ongoing distress suggests that respondents still engaged with insurance companies at 6-month follow-ups may be vulnerable to the onset or exacerbation of depression or anxiety disorders if their disputes are not satisfactorily resolved [29]. The distinction between natural distress and adverse mental health outcomes and the difficulty distinguishing them in the aftermath of a natural disaster [9,12] underlines the importance of appropriate follow-up over time so that clinicians can distinguish between those suffering transient distress from those in need of ongoing mental health support.

Our qualitative results suggest possible improvements to the support available during recovery. As in previous studies [5,16], we find that the stress of managing one's own recovery and dealing with applications for support, insurance and other bureaucracies may itself be a significant secondary stressor. Appropriate administrative support from experienced personal "advocates" for the completion of these tasks may mitigate the stress they cause and improve their completion and success rates. There are support services provided by the Insurance Council of Australia and Legal Aid, but clearly many consumers were unaware or unable to access them.

It may also be necessary to introduce "standard" insurance policies similar to the practice of standardised tenancy leases, that cover all damage sustained due to government-declared disasters.

Delayed recovery as a result of ongoing insurance dispute is a strong theme in our qualitative data and in previous studies [7,9,11]. The process may be expedited by a policy that allows clean-up and repairs to commence once the damage has been properly documented.

Conceptually, our results suggest distinct trauma mechanisms for flood-affected individuals who are in dispute with insurance companies: the primary (flood event) and secondary (in our case insurance dispute). In the first instance, there may be a primary traumatic impact in the early months from a high level of flood exposure, resulting in PTSD and anxiety. The trauma may cause PTSD symptoms such as flashbacks and nightmares, and anxiety about future occurrences, housing and work issues and financial problems. Later, there may be a secondary impact of insurance disputes and rejected claims, which if not rapidly resolved may manifest primarily as ongoing distress, depression and anxiety.

Depression is often associated with experiences of loss or deprivation [30]. It is therefore a likely consequence of insurance disputes and rejection which involve enduring property damage and financial or property loss. Anxiety is typically associated with future threat [30]. It is therefore a likely consequence of the threat of ongoing financial and housing issues. The qualitative responses support these interpretations in identifying financial losses, delays in a return to normalcy and uncertainty of outcome as key influences on the mental health and wellbeing of respondents.

Our results also point to a lack of effective policy responses to ongoing disaster insurance issues. In 2011, the Australian Government undertook a review of disaster insurance [31]. The findings from the present study highlight that many of the issues identified during the 2011 review remain problematic many years later, including affordability, clarity of coverage, consumer awareness, claims handling, dispute resolution and delays.

Insurance companies should also note that, after a disaster, a relatively small number of rejected or disputed claims can translate into broad community disaffection with the services they provide.

Strengths and Limitations

This work contributes in several ways to our understanding of recovery from flooding, and the potential for insurance disputes to significantly impede that recovery. The reporting of four distinct mental health outcomes provides insights into the complexity of individuals' responses to both the primary and secondary stressors we studied. Furthermore, the current work appears to be the only study which has collected such survey data in the first year post-flood or combined quantitative and qualitative data to articulate the particular concerns of affected individuals. There are some limitations that should be noted. The quantitative study cohort could be better defined. We had no direct survey response that participants made a flood-related insurance claim, only that they were inundated and did not deny having coverage.

One outcome measure is overly broad. The "ongoing distress" survey item is likely to capture a broad range of circumstances from adverse mental health outcomes to frustration and anger as recovery is delayed or denied. It would have been useful to include more items to further understand its contributing factors.

The small numbers preclude a thorough analysis of possible confounding from associations between demographic factors and insurance dispute. In particular, homeowners and older respondents had the lowest dispute rate. STATA's margins command revealed no substantial confounding from these sources.

5. Conclusions

This work informs our understanding of recovery from flooding in several ways. The distinct patterns of influence of the primary and secondary stressors on the four mental health outcomes have sketched the complexity of these stressors' impacts on mental health and provided some tentative first steps towards a causal model.

There are implications for counsellors and support workers, who should be mindful of the unfolding of mental health responses to flooding trauma and subsequent secondary stressors such as insurance dispute. In the medium term, a lack of return to normalcy is likely to be a sign that possible distress and depression need to be monitored, including amongst those who appeared to cope well with the initial disaster.

Finally, this work underlines the need for clarity in insurance coverage as well as for support in the management of victims' disaster recovery.

It remains a profound irony that processes designed to support recovery, such as home and contents insurance, can in practice act as serious additional stressors.

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Informed Consent Statement: Completion of the questionnaire was taken as consent to participate in the study. Preliminary text clearly stated that survey participation was optional and that participants could withdraw at any stage.

Data Availability Statement: The datasets used and analysed during the current study are available from The University Centre for Rural Health on reasonable request.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Relevant Survey Items

Free Text:

1. Is there anything on your mind that you want to say right upfront about the heavy rain and flood in March/April 2017?
6. Did you have to evacuate your home?
   Is there anything more you want to say about this?
9. Did you have to evacuate the business you own or the place where you work?
   Is there anything more you want to say about this?
15. In your view, are any of the following organisations [Insurance company] to blame for anyone's distress after the flood?
    Is there anything more you want to say about this?
16. Were you in the Northern Rivers when the heavy rain fell in June 2017 (about 3 months after the March/April flood)?
    If Yes, did this affect you in any way? If so, how?
45. Thinking back, have the severe rain and flood resulted in you being able to make any positive changes in your life?
    If yes: Could you give an example of your positive changes?
58. Is there anything else you want to add about your experience of the March/April flood or what things are like for you now?
    Feedback: If you have any queries, suggestions or feedback, please use the space below (you can use the space on the back page if you need more room).

Event Specific Multiple Choice:

4. Were non-liveable areas of your home damaged or flooded (e.g., garage, garden shed)?
   Options: Yes/No
5. Was at least one liveable room in your home damaged or flooded (e.g., bedroom, living room, kitchen, bathroom)?
   Options: Yes/No
11. Did any of the following happen at the time of the March/April flood or afterwards? (Please tick all that apply)

    You believed you were fully insured but the insurance company rejected or disputed your claim
14. After the March/April flood, did the support you requested or received from the following organisations or groups meet your needs?—Insurance company
    Options: No/Partially met my needs/Fully met my needs/Don't know/N/A
15. In your view, are any of the following organisations to blame for anyone's distress after the flood?—Insurance company
    Options: Not at all/Partly/A lot/Entirely

Demographics:

26. How old are you? [years]
27. Where were you born?
    Options: Born in Australia/Born overseas

28. What language do you speak at home?
    Options: Mainly English/Mainly a language other than English
29. Are you of Aboriginal or Torres Strait Islander origin?
    Options: Yes, Aboriginal/Yes, Torres Strait Islander/Yes, both Aboriginal and Torres Strait Islander/No
30. Are you ...?
    Options: Female/Male/Other
31. Do you consider yourself to be:
    Options: Lesbian, gay or homosexual/Straight or heterosexual/Bisexual/Queer/Transgender/Other
32. What is your relationship status?
    Options: Single/Married or other formal commitment/In a relationship but not living together/Living together (in a defacto relationship)
34. Have you completed any formal education? (Please tick all that apply)
    Options: Year 10 certificate (or equivalent)/Year 12 certificate (or equivalent)/Diploma or trade (e.g., child care, hairdresser, chef)/University degree/None of the above/Other (please specify)
35. Are you currently in paid work? (Please tick all that apply):
    Options: Part-time work/Full-time work/No/Casual work (hours vary & are not set)/Shift-work
37. What was your housing situation at the time of the March/April 2017 flood?
    Options: Renting/Had a mortgage/Owned home outright/Other (please specify):
40. At the time of the March/April flood, were you receiving any income support from the government? (Please tick all that apply)
    Options: Age-related pension/Youth allowance/Newstart/Disability support pension/Parenting payment/None of these/Other (please specify):
42. What is your approximate total household income per year before tax?
    Options: Under $50,000/$50,000–$100,000/Over $100,000/Prefer not to answer

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ORIGINAL PAPER

Social vulnerability in a high-risk flood-affected rural region of NSW, Australia

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Abstract

We describe factors related to the social vulnerability of populations that experienced major river flooding in northern New South Wales (NSW), Australia. Using geographical information system methods, maps of 2017 flood-affected areas in the Lismore and Murwillumbah regions were combined with 2016 National census data to compare aspects of social vulnerability with the wider region and the region with Sydney. We also used individual-level data from the NSW 45 and Up Study to compare lifestyle, behavioural and health characteristics of residents of these flood-affected areas with the broader region ($n = 13{,}561$). Populations living in the Lismore Town Centre flood footprint exhibited significantly higher levels of social vulnerability over a range of factors; in particular, almost 82% resided in the most disadvantaged socio-economic quintile neighbourhoods. The flood-affected areas of Murwillumbah and Lismore regions included 47% and 60% of residents in the most disadvantaged quintile neighbourhoods compared to 27% for whole region and 16% for Sydney. This pattern of increased vulnerability was also apparent from the 45 and Up study; participants residing in the Lismore Town Centre flood footprint had significantly higher rates of riskier lifestyle-related behaviours (smoking, alcohol consumption), pre-existing mental health conditions (depression and anxiety) and poorer health. This detailed case study demonstrates extreme local vulnerability of flood-exposed populations, over and above the already highly vulnerable regional rural populations. This information is important to inform disaster planning and response and also reinforces the importance of having a detailed understanding of affected populations.

Keywords Floods · Vulnerable populations · Resilience psychological · Disasters · Socio-economic factors · Community

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1 Introduction

Weather-related disasters can impact populations economically, socially and health-wise (Berry et al. 2018). Globally flooding has been one of the most common of these disasters (Hu et al. 2018, Alderman et al. 2012). Australia frequently suffers from flood disasters, and this is expected to increase (Hu et al. 2018).

The north east of NSW is a hotspot flood area, having the greatest number of flood disaster declarations across the state between 2004 and 2014 (Sewell et al. 2016). The recent 2017 flood event experienced in the north-east area of NSW provides the opportunity to investigate aspects of social vulnerability in a high-risk flood area in rural Australia.

In March/April 2017, rainfall from ex-Tropical Cyclone Debbie affected many residents in the Northern Rivers area of NSW, especially around Lismore (Wilson and Richmond River valleys), Murwillumbah (Tweed River Valley), and other smaller townships. While Lismore has a history of frequent flooding (4 major and 6 minor flood events from 2004), the town recorded its wettest March day in more than 100 years (Gergis 2017) during the 2017 event, resulting in the breech of the town's flood levee and flooding the central business district. Based on flood height classifications, this flooding was considered to be a major flood event (Dakin 2017).

The first priority of the Sendai Framework for Disaster Risk Reduction 2015–2030 is to understand disaster risk, including vulnerability in order to improve disaster risk management policies and practices (UNISDR 2015a, b). It is therefore important to describe the socio-demographic characteristics of populations susceptible to natural disasters to better plan and mitigate these impacts in future disasters (Berry et al. 2018).

Vulnerability can be viewed as being both physical and social, and these two factors can interact in complex ways. Physical vulnerability relates to the natural environment, while social vulnerability relates to social, economic, political and institutional conditions that precede a disaster event like flooding (Lee 2014; Fekete 2010; Simpson and Human 2008). Rufat et al. (2015) through the analysis of 67 case studies identified key empirical drivers of social vulnerability to floods including demographic characteristics (gender, age, ethnicity, family structure, language ability), socio-economic status (income, education, employment), health (disease, stress), land tenure, risk perception and coping capacity. This systematic review provides a detailed examination of social vulnerability indicators. For demographic indicators, the role of gender and age may be geographically and contextually driven, such that increased rates of vulnerability could be attributed to being female, young or elderly in some circumstances but not in others. Increased vulnerability was clearer for single-parent families, being non-white, having reduced capacity for self-care and having language barriers (Rufat et al. 2015 Table A1). For socio-economic factors, poverty, low income, unemployment and not completing high school were the most common drivers for increased vulnerability (Rufat et al. 2015 Table A2). Lower levels of education can coincide with low income, unemployment or residing in rental accommodation, compounding the damaging impact of flood on their capacity for recovery.

Simpson and Human (2008) and Kleinosky et al. (2007) used broadly similar factors to assess social vulnerability along with racial, disability and mobility factors. A qualitative survey of service providers (Khalili et al. 2015) identified drivers of community vulnerability as well as factors supporting social cohesion and collective efficacy.

The social vulnerability of people experiencing floods has been widely investigated (Walker and Burningham 2011); Fielding 2018; Alderman et al. 2012; Lee 2014; Rufat et al. 2015; King 2001; Buckle et al. 2000) and has demonstrated that the most

disadvantaged groups often experience disproportionate exposure to flood events (Fielding 2018; Walker and Burningham (2011); Sewell et al. 2016) and flood impact (Walker and Burningham 2011). This is particularly important because these groups often have limited ability or resources to aid recovery (Fielding 2018) and also have increased mental health problems as a result of the flood experience (Milojevic et al. 2017). We note that much of the social vulnerability literature has focused on the construction of composite indices (for example, Fekete 2010; Remo et al. 2016; Fatemi et al. 2017) while the current work's primary focus is on individual factors.

The increasing availability of electronic flood maps and geographic information system (GIS) technology enables more precise descriptions of the social vulnerability of residents of flood-affected locations. Administrative data collections such as routinely available census data can provide demographic and economic information but often have limited data on individual lifestyle- and health-related factors, whereas data from existing health cohort studies may be able to fill this gap. Fortunately, the NSW 45 and Up Study, a survey of more than 266,000 healthy ageing residents of NSW (Gubhaju et al. 2013), has collected demographic, economic information, lifestyle- and health-related information for residents aged 45 and older for all NSW including our study area.

Rufat et al. (2015) concluded that empirical case studies are needed because they provide 'a rich source of situational understanding of the root causes of social vulnerability….' p. 480, and this is echoed in the Sendai Framework for Disaster Risk Reduction calling for more localised reporting and analyses of natural disasters. Given the high economic costs of flooding (ABRDRSC 2015) and the impact on people's quality of life, it is important to understand the social vulnerability characteristics and potential inequities of those living in flood-affected rural areas in particular, which is important in disaster planning on both local and wider levels.

This study took a detailed empirical case study approach to quantifying social vulnerability factors and assessing the degree of disadvantage in a high-risk flood-affected rural region of northern NSW, Australia, which was affected by the 2017 March/April flood, using both administrative census and cohort study data.

2 Methods

2.1 Flood maps

The NSW Office of Environment and Heritage (OEH) (2014) provided maps of the 2017 flood for the Murwillumbah–Tweed area based on the Tweed River and for the Lismore Town Centre with reference to the Wilson River. These maps were derived from models of the actual 2017 flood event, which included rainfall data and river flows with other hydrological inputs, and were the most accurate and up-to-date information available (as of April 2018, personal communication from NSW OEH). The 2017 flood event was similar to the 1 in 100-year event estimates for the Murwillumbah and surrounding areas with reduced severity towards the coast (ref: personal communication Tweed Shire Council), and this is referred to throughout this paper as the '2017 Murwillumbah Region Flood footprint'.

The 2017 Lismore flood map from OEH had a peak river height at the Rowing Club gauge of 11.5-m AHD (Australian Height Datum) (equivalent to 1 in 40-year event—personal communication Lismore City Council) and is referred to as the '2017 Lismore Town Centre Flood footprint'. The 2017 Lismore Town Centre Flood footprint is a subregion of

the full extent of the 2017 flood in the Lismore area. The Lismore City Council provided a map of the extent of the highest known flood event (12.2 m AHD, equivalent to 1 in 70-year event), which took place in 1974. The 1974 event was significantly bigger than the 2017 event in terms of flood peak and the flooded physical area, but is the best indication of an actual flood event similar in nature to that of 2017 for the wider Lismore region. This 1974 Lismore map is used in this paper as indicative of the 2017 flood extent for those residents in the wider Lismore region. For ease of interpretation, this extent is defined as the '1974 Lismore *Region* Flood footprint' throughout the paper.

2.2 Overlay flood maps with census data

Geographic information system (GIS) software (ARCGIS version 10.1) was used to overlay the electronic maps of the 2017 flood footprints as described above with a range of socio-demographic data from the ABS 2016 population census data. Every 5 years in Australia, the Australian Bureau of Statistics (ABS) conducts a population census that measures important socio-demographics such as housing, ethnic background and employment, with the latest Census being conducted in 2016. Census data allows the ABS to drill down into small geographical areas to identify local population characteristics (ABS 2018a). ABS General Community Profiles provides data on the social, economic and demographic characteristics of specified geographic areas. The geographical profiles can provide aggregated data on a personal, family or household level (ABS 2018b).

Census data are available by ABS Australian Statistical Geography Standard (ASGS) with the smallest area being a meshblock (MB) (30–60 dwellings). Some MBs have no dwellings by design due to their land use, where land-use categories include residential, commercial, industrial, primary production, medical, education, and parkland. These MBs are aggregated in turn to statistical area (SA) levels 1–4 (SA1, SA2, SA3, SA4) which increase in size (ABS 2016b, c).

The Northern Rivers region of NSW is defined by the SA4 of 'Richmond-Tweed' which is an aggregation of 22 SA2s or 4223 MBs. The boundaries of the flood maps do not coincide with these spatial units. Therefore, an area-based approach was used, followed by population weighting, based on the number of people at their usual place of residence (URP) and dwellings at a meshblock level from 2016 census data (ABS 2016a) to adjust the published socio-demographic data (available for SA1 areas) for the irregular shapes of the flood boundaries.

GIS methods were used to intersect MBs with the flood boundaries and aggregate the MB population and dwellings from the 2016 ABS Census to obtain respective flood area numbers, which were then summed to SA1 areas. This provided more accurate flood population estimates by taking into account MBs which had no dwellings or residents due to their land use (e.g. Parkland). Estimated Resident Population (ERP), the official population measure for Australia, is based on the usual residence counts (URP) with adjustments for Australian residents temporarily overseas and international visitors. MB Estimated Resident Population ERPs 2016 estimates were obtained using proportional weighting with ERP data for 2016 by SA1s (Queensland Government Statistician's Office 2018).

The flood-impacted population and dwellings as a proportion of the complete SA1 population and dwellings were calculated and used to obtain flood estimates for social vulnerability drivers from the ABS 2016 General Community Profile SA1 statistics (ABS 2018c). The Greater Sydney Statistical area structure, which covers the wider Sydney area, is an aggregation of SA4s.

Throughout the paper, 'flood affected' or 'flood impacted' is defined as those people or dwellings contained in any of the flood footprint maps detailed earlier. It should be noted that in the Richmond-Tweed SA4 other areas were inundated besides the three flood footprints in the present study. Accurate 2017 flood maps for these additional areas were not available. For this reason, the study's key comparisons are between these flood-impacted areas and the whole Richmond-Tweed SA4.

2.3 Social vulnerability drivers: collected census data

Socio-economic status (SES) was defined as the ABS 2016 Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-economic Disadvantage (IRSD). The 2016 IRSD score (ABS 2018d) is based on 2016 Census measures of income, education, employment, housing, and other aspects of household/family disadvantage. The IRSD scores are also provided as national- and state-based quintiles where '1' indicated the most disadvantaged 20% and '5' the least disadvantaged 20%. NSW-specific quintiles were used throughout this paper.

All other demographic population characteristics were derived from General Community Profile Census 2016 information Census Data Packs (ABS 2018b) for SA1s or General Community Profiles for SA4 for Richmond-Tweed, and Greater Sydney area and were based on individuals and dwellings or households. See Supplementary file 1 for details of social vulnerability drivers and related General Community Profile tables.

Personal and family household incomes were assessed, with rates of low income assessed in two ways for both individuals and family households. The first measure is the proportion below the NSW 2016 median weekly income ($650 and $1750 for individuals and family households, respectively) and the second a definition of poverty as below half of the median income (Tsumori et al. 2002; SPRC 2016). Due to the categories of income reported by ABS, we defined poverty for individuals as weekly income below $300 and $800 for family households.

2.4 Health- and Lifestyle-related vulnerability indicators

The 45 and Up Study (Gubhaju et al. 2013; Banks et al. 2008) collected demographic, lifestyle- and health-related data for more than 266,000 residents recruited during 2006–2009. The study over-sampled those over 80 years of age as well as rural residents by a factor of two. This enabled adequate numbers for our study area. The baseline survey achieved an 18% response rate with 11% coverage of the target population (Banks et al. 2008). This study was the largest population-based cohort study in Australia and is considered to be relatively heterogeneous, with a good spread of responses across most variables. Although derived from the general population, the relatively low response rate means that the cohort is unlikely to be directly representative of the general population. However, it can provide a good basis for investigations based on internal comparisons (Banks et al. 2008).

Consent for linkage to routine health databases, including the death registry, was obtained from participants. Each participant's residential address was geocoded to longitude and latitude to enable linkage with geographic data such as 2011 ABS statistical areas and respective flood maps.

Participants who were resident in the Richmond-Tweed SA4 Statistical area at recruitment (2006–2009) were included, but those known to have died between 2007 and 2015 (from linked death registrations) were excluded from our analysis. The following baseline

variables from the 45 and Up Study were included in our assessment of flood-affected populations: gender, age (45–54, 55–64, 65 and over), low income (less than $20,000 per annum), working status, current smoking status, alcohol consumption (high = more than 14 drinks per week), obesity (BMI > 30), self-rated health (poor or fair). Variables that were indicators of mental health were also investigated including treated for depression or anxiety and psychological distress (K10 > 21). K10 is the Kessler 10 item Psychological Distress Scale where a score over 21 indicates a high level of distress (ABS 2012). ABS SEIFA data from 2011 (ABS 2013) were also linked to the participants, thus enabling the SES to be measured by the 2011 IRSD in terms of NSW-based quintiles.

The data collection of the 45 and Up Study was approved by the University of New South Wales Human Research Ethics Committee (HREC). The 45 and Up component of this paper was approved by the NSW Population and Health Services Research Ethics Committee (reference: HREC/15/CIPHS/4), and the Cancer Institute NSW (reference: 2015/02/575 Air Pollution, Traffic Exposures and Mortality and Morbidity in Older Australians (APTEMA) Study with amendments which included additional environmental measures). The Centre for Health Record Linkage (CHeReL) linked the death registration data from the NSW Births, Deaths and Marriages.

2.5 Statistical analysis

As most of the data were available at an aggregated level by socio-demographic categories, X^2 tests of associations were used to compare flood footprint social vulnerability drivers with the wider Richmond-Tweed area. In order to demonstrate the relative disadvantage of the rural area of Richmond-Tweed with the metropolitan area of Sydney, X^2 tests of associations were used. Due to the multiplicity of comparisons (four per variable), statistical significance was set to the $p < 0.01$ level.

ARCGIS 10.1 was used for spatial mapping, SPSS version 22, for estimates of indicators or drivers of social vulnerability and statistical comparisons. Microsoft Excel was used to assist with the collation of demographic data. SAS 9.2 was used for statistical analysis for 45 and Up Study data through the SURE (Secure Unified Research Environment) remote-access data research laboratory of the SAX Institute.

3 Results

Figure 1 illustrates the NSW North Coast area (Richmond-Tweed (SA4) with '2017 Murwillumbah Region Flood footprint' the '2017 Lismore Town Centre Flood footprint' and the 1974 Lismore Region Flood footprint'.

3.1 The regional context: Richmond-Tweed SA4 compared to the Greater Sydney Area

This section aims to set the regional context for this study. The demographic and economic regional profile is starkly different to that for the (urban) Greater Sydney region.

Overall, the Richmond-Tweed region exhibited significantly higher rates of socio-economic disadvantage compared to the Greater Sydney area ($X^2 = 99{,}174$, $p < 0.001$) as seen in Table 1 with a significantly greater proportion of people in the lowest SES categories

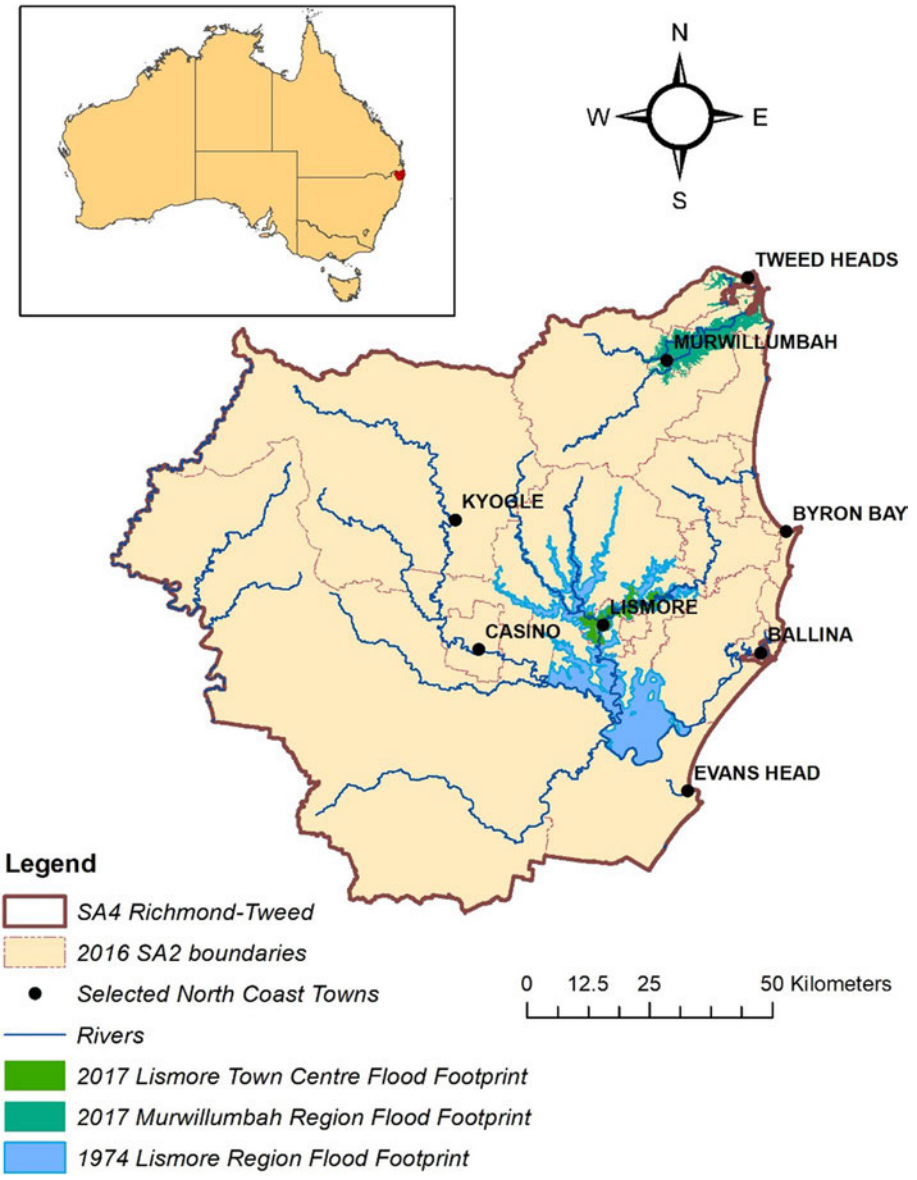

Fig. 1 Northern Rivers NSW (Richmond-Tweed SA4) with flood maps for the 2017 Lismore Town Centre Flood footprint (OEH sourced), extended to the 1974 Lismore Regional flood footprint (Lismore City Council sourced) and 2017 Murwillumbah Region Flood footprint (OEH sourced)

(26.5% compared to 15.7%) and significantly fewer people in the least disadvantaged SES grouping (3.8% compared to 27.8%).

The urban–rural differences between Sydney Area and the Richmond-Tweed, a predominantly rural area of NSW, are illustrated in Table 2, and all were significantly different ($p < 0.001$) (Supplementary File 3). This illustrated the extent of relative social

Table 1 The Richmond-Tweed (SA4) and Greater Sydney area by SES NSW quintiles (2016)

	Richmond-Tweed SA4	Greater Sydney area
Population (URP)	239,604	4,984,740
SES quintiles	%	%
1 Most disadvantaged	26.5	15.7
2	28.5	16.0
3	25.8	18.2
4	15.5	22.3
5 Least disadvantaged	3.8	27.8

Table 2 Demographic and socio-economic characteristics of flood footprints, Richmond-Tweed SA4 and Greater Sydney area (based on 2016 ABS Census data)

	Richmond-Tweed SA4	Greater Sydney area
Usual resident population (*N*)[#]	239,604	4,823,991
Demographics	%	%
Female	51.5 (51.2–51.7)	50.7 (50.7–50.8)
Children 0–14	17.1 (16.9–17.3)	18.7 (18.6–18.7)
Aged 15–64	60.3 (60.1–60.6)	67.4 (67.3–67.5)
Aged 65 and older	22.5 (22.3–22.7)	13.9 (13.9–14.0)
Aboriginal and/or Torres Strait Islander	4.1 (4.0–4.2)	1.5 (1.4–1.5)
Live alone[a]	14.8 (14.6–15.1)	9.7 (9.7–9.8)
Need assistance	6.5 (6.4–6.6)	4.9 (4.9–4.9)
Single-parent families[b]	19.5 (19.1–20.0)	15.9 (15.8–16.0)
Economic drivers		
Individual poverty (< $300 pw)[a]	18.0 (17.8–18.2)	21.6 (21.6–21.7)
Individual low income (< $650 pw)[a]	51.0 (50.7–51.3)	42.7 (42.7–42.8)
Education completed high school[a]	40.8 (40.5–41.1)	62.1 (62.0–62.2)
Unemployed[c]	7.0 (6.8–7.2)	6.0 (6.0–6.1)
Family household poverty (< $800 pw)[b]	20.4 (20.0–20.8)	2.2 (2.2–2.3)
Family household low income (< $1750 pw)[b]	55.2 (54.7–55.7)	12.3 (35.5–35.7)
Rented dwellings[d]	27.9 (27.6–28.3)	34.1 (34.0–34.2)

[a]Denominator persons aged 15 and over (denominator = 176,751, 3,608,554 in column order)

[b]Denominator is family households (denominator = 60,795, 1,195,662 in column order)

[c]As percentage of persons in labour force; (denominator = 103,710, 2,418,399 in column order)

[d]Denominator is sum of owned outright, owned mortgage, rented dwellings (denominator = 90,951, 162,387 in column order). Statistical comparisons are in Supplementary file 3

vulnerability of the Richmond-Tweed area, with significantly higher proportions of older residents, living alone, being unemployed, needing assistance, not completing Year 12 of high school, being a single parent and identifying as Aboriginal and/or Torres Strait Islander. Economic vulnerability was also demonstrated with relatively high rates of family household poverty (18% for Richmond-Tweed versus 2% in Sydney) and lower median household incomes.

3.2 Estimates for the flood-affected areas

Approximately 13,500 people and around 6200 dwellings were flood-affected based on the 2017 Lismore Town Centre Flood footprint and the 2017 Murwillumbah Region Flood footprint (Table 3). However, using the 1974 Lismore Region Flood footprint and the 2017 Murwillumbah Region Flood footprint, this increased to about 18,700 people and 8100 dwellings.

For the two Lismore flood footprints, 171 and 326 MBs were affected but for both only two SA2s were impacted (Lismore and Lismore region). The 2017 Murwillumbah Region Flood footprint covered both the Murwillumbah inland area through to the coast with more than 530 MBs and seven SA2s affected.

For the 2017 Lismore Town Centre Flood, 2017 Murwillumbah Region Flood and 1974 Lismore Region footprints as expected the residential land-use MBs accounted for the majority of flood-affected people (78%, 83%, 63%) and dwellings (78%, 85%, 64%) with agricultural MBs accounting for the largest areas of land that were flood-affected (67%, 83%, 94%), respectively. The 2017 Murwillumbah Region and the 1974 Lismore Region footprints were similar in their agricultural land coverage, 83% and 93%, respectively, whereas the Lismore Town Centre footprint was primarily confined to the urban town area of Lismore (Table 3).

3.3 Measures of social vulnerability

Overall, the Richmond-Tweed region was seen to exhibit significantly higher rates of socio-economic disadvantage compared to the Greater Sydney area.

Within the Richmond-Tweed region, socio-economic disadvantage is strongly concentrated in the areas most susceptible to flooding. Table 4 shows that over 80% of people in the 2017 Lismore Town Centre flood-affected area were living in the lowest socio-economic neighbourhoods; staggeringly 90% were in the lowest two quintiles compared to only 55% for Richmond-Tweed and 40% for all of NSW. Similarly, 65% in the 2017 Murwillumbah flood footprint and 75% in the 1974 Lismore Region footprint were in the lowest two quintiles. At the opposite end of the scale, in general, less than 2% of flood-affected people resided in the least disadvantaged SES neighbourhoods in stark contrast to the 20% of the NSW population. All these flood footprints were significantly different to the wider Richmond-Tweed area ($p < 0.0001$) by primarily having an overrepresentation in the most disadvantaged SES quintile (Table 4).

Table 5 reports individual-based and household-based demographic characteristics for the three flood footprints from the 2016 ABS Census data.

Increased social vulnerability was most evident comparing the 2017 Lismore Town Centre Flood footprint to Richmond-Tweed (Table 5). There are significantly ($p < 0.001$) higher rates of people living alone, unemployed, low-income individuals and households, rented accommodation, single-parent households and Aboriginal or Torres Strait Islander residents, as well as lower rates of Year 12 education and older residents (Supplementary File 3). The 1974 Lismore Region Flood footprint showed a similar pattern although it did not differ to the Richmond-Tweed area in regard to the proportion of Aboriginal or Torres Strait Islander residents, those living alone, income level, unemployment rate, single-parent families, or those renting accommodation.

Table 3 Estimated flood extent (ERP, URP, dwellings and area flooded) for the 2017 Lismore Town Centre Flood, 2017 Murwillumbah Region Flood and 1974 Lismore Region footprints using ABS Census 2016 data

Estimated population ERP	2017 Lismore Town Centre Flood footprint			2017 Murwillumbah Region Flood footprint			1974 Lismore Region Flood footprint		
	5064			8416			9321		
	Persons URP	Dwellings (*n*)	Area (km^2)	PersonsURP	Dwellings (*n*)	Area (km^2)	Persons URP	Dwellings (*n*)	Area (km^2)
Totals	4982	2253	43	8222	4023	126	9159	4097	388
By land use[a]									
Residential	3900	1748	7	6823	3417	8	5732	2641	9
Agricultural	439	172	30	1094	451	105	2613	1042	362
Other	643	333	6	305	155	13	814	414	6

Population estimates based on MB/SA1 population weighting

[a]Land use: other includes commercial, industrial, education, Hospital Medical, Parkland categories

Table 4 Percentage of residents by SES NSW quintiles for the flood footprints and the Richmond-Tweed (SA4)

	2017 Lismore town centre flood footprint	2017 Murwillumbah region flood footprint	1974 Lismore region flood footprint	Richmond-Tweed SA4
Population (URP)	4982	8212	9159	239,604
SES quintiles	%	%	%	%
1 Most disadvantaged	81.8	47.0	59.7	26.5
2	7.8	17.5	14.9	28.5
3	7.4	31.8	20.4	25.8
4	1.8	3.6	3.3	15.5
5 Least disadvantaged	1.2	0.0	1.6	3.8

When compared to the Richmond-Tweed area overall, the 2017 Murwillumbah Region flood area had a significantly higher proportion of older people, low-income individuals and households, single-parent families, as well as fewer children and year 12 education.

These results demonstrate that people living in a flood-affected area had significantly increased social vulnerability on a wide range of measures when compared to the already vulnerable Richmond-Tweed region, although the degree of this differed depending on the flood area under investigation.

3.4 Measures of health and lifestyle

Table 6 provides the results for the three flood footprints with gender, age, health- and lifestyle-related measures for the more than 13,500 45 and Up Study participants who were resident in the Richmond-Tweed region at the baseline data collection and who were potentially still resident in the area at the time of the 2017 flood event.

The 45 and Up baseline data (2006–2009) for the three flood footprints provides a similar pattern to that of the ABS 2016 census data with respect to gender, age and SES distributions, despite the temporal differences.

The 2017 Lismore Town Centre Flood footprint residents again exhibit the most vulnerability with 90% in the lowest two quintiles of SES 2011, compared to 83% and 74% in the 2017 Murwillumbah Region and 1974 Lismore Regional flood areas, although all differed significantly from the wider Richmond-Tweed area (54%).

The participants in the 2017 Lismore Town flood footprint had proportionally more individuals in the lowest income group ($p=0.003$). In this area, there were significantly fewer in the over 65 age group ($p<0.001$). These participants also exhibited significantly riskier lifestyle- and health-related characteristics to the rest of the Richmond-Tweed (Table 6). They exhibited higher rates of smoking ($p<0.001$), high alcohol consumption ($p=0.002$), poor or fair self-rated health ($p<0.001$), high psychological distress ($p=0.002$), and close to double the rates of being treated for anxiety ($p=0.014$) and depression ($p=0.013$).

The study participants in the 2017 Murwillumbah Region Flood footprint were not significantly different for any of the lifestyle- or health-related characteristics from the wider Richmond-Tweed, and the participants in the 1974 Lismore Region Flood footprint only had significantly higher smoking rates ($p<0.001$) and fewer older residents ($p<0.001$).

Table 5 Demographic and socio-economic characteristics of flood footprints and the Richmond-Tweed SA4 (based on 2016 ABS Census data) with 99% confidence intervals

	2017 Lismore town flood footprint	2017 Murwillumbah region flood footprint	1974 Lismore region flood footprint	Richmond-Tweed SA4
Usual resident population (N)[#]	4961	8228	9126	239,604
Demographics	%	%	%	%
Female	48.3 (46.5–50.1)	50.8 (49.4–52.3)	49.3 (48.0–50.7)	51.5 (51.2–51.7)
Children 0–14	17.1 (15.8–18.5)	14.9 (13.9–15.9)	17.3 (16.3–18.3)	17.1 (16.9–17.3)
Aged 15–64	68.0 (66.2–69.6)	56.1 (54.7–57.5)	66.7 (65.4–67.9)	60.3 (60.1–60.6)
Aged 65 and older	14.9 (13.6–16.3)	29.0 (27.7–30.3)	16.0 (15.1–17.0	22.5 (22.3–22.7)
Aboriginal and/or Torres Strait Islander	6.7 (5.8–7.6)	4.6 (4.0–5.2)	5.4 (4.8–6.0)	4.1 (4.0–4.2)
Live alone[a]	16.1 (14.6–17.6)	15.8 (14.7–17.0)	12.0 (11.1–12.9)	14.8 (14.6–15.1)
Need assistance	6.9 (6.0–7.9)	8.0 (7.3–8.8)	6.3 (5.7–7.0)	6.5 (6.4–6.6)
Single-parent families[b]	30.4 (28.6–32.3)	32.2 (30.8–33.8)	25.8 (23.5–28.3)	19.5 (19.1–20.0)
Economic drivers				
Individual poverty (< $300 pw)[a]	20.8 (19.2–22.5)	17.7 (16.6–18.9)	20.1 (18.9–21.3)	18.0 (17.8–18.2)
Individual low income (< $650 pw)[a]	57.1 (55.1–59.1)	55.8 (54.2–57.3)	54.4 (52.9–55.9)	51.0 (50.7–51.3)
Education completed high school[a]	36.5 (34.5–38.5)	33.9 (32.5–35.4)	37.0 (35.6–38.5)	40.8 (40.5–41.1)
Unemployed[c]	12.0 (10.3–13.9)	8.0 (6.8–9.3)	9.7 (8.5–10.9)	7.0 (6.8–7.2)

Table 5 (continued)

	2017 Lismore town flood footprint	2017 Murwillumbah region flood footprint	1974 Lismore region flood footprint	Richmond-Tweed SA4
Family household poverty (< $800 pw)[b]	21.1 (18.0–24.4)	24.0 (21.7–26.5)	19.5 (17.4–21.8)	20.4 (20.0–20.8)
Family household low income (< $1750 pw)[b]	58.9 (55.0–62.7)	58.1 (55.3–60.9)	56.6 (53.8–59.3)	55.2 (54.7–55.7)
Rented dwellings[d]	37.3 (34.4–40.2)	24.2 (22.3–26.1)	35.6 (33.5–37.7)	27.9 (27.6–28.3)

Numbers from Mesh Block URP and dwellings 2016 were proportional weighted by flood area and aggregated to SA1 statistical areas, these proportions were then applied to General Community Profile results for respective SA1s. Note that small random adjustment has been made by ABS in the production of the General Community Profile Tables to protect confidentiality., which may result in differing total URPs to earlier tables

[a]Denominator persons aged 15 and over (denominator = 4118, 7004, 9126, 176,751 in column order)

[b]Denominator is family households (denominator = 1085, 2083, 2139, 60,795 in column order)

[c]As percentage of persons in labour force (denominator = 2147, 3219, 4114, 103,710 in column order)

[d]Denominator is sum of owned outright, owned mortgage, rented dwellings (denominator = 1883, 3332, 3443, 90,951 in column order). Statistical comparisons are in Supplementary file 3

Table 6 45 and Up study participants' characteristics with 99% confidence intervals

	2017 Lismore Town Centre Flood footprint	2017 Murwillumbah Region Flood footprint	1974 Lismore Region Flood footprint	Richmond-Tweed SA4
Numbers of participants (N)	150	479	458	13,561
Demographics—economic	%	%	%	%
SES 2011				
Quintile 1 most disadvantaged	85 (76–91)	29 (24–34)	66 (60–72)	27 (26–28)
Quintile 2	5 (2–12)	54 (46–58)	8 (5–12)	26 (25–27)
Quintile 3	7 (3–13)	11 (8–15)	21 (16–26)	27 (26–28)
Quintile 4–5 Least disadvantaged	3 (1–9)	8 (5–11)	5 (3–8)	20 (19–21)
Gender female	49 (39–60)	52 (38–46)	55 (49–61)	57 (46–58)
Age 45–54	44 (34–55)	30 (25–36)	42 (36–48)	32 (31–33)
55–64	37 (21–43)	37 (32–43)	38 (32–44)	34 (33–35)
65 and older	19 (12–29)	32 (27–38)	21 (74–84)	34 (33–35)
Low income (< $20 k per annum)	32 (22–42)	21 (16–26)	22 (17–27)	23 (22–24)
Work status—working	53 (43–64)	48 (42–54)	58 (52–64)	48 (46–49)
Lifestyle- and health-related				
Current smoker	19 (12–29)	8 (6–12)	13 (9–17)	7 (7–8)
High alcohol consumption	23 (15–33)	16 (12–20)	19 (14–24)	17 (16–17)
Self-rated health (poor or fair)	22 (14–31)	12 (8–15)	12 (9–17)	11 (10–12)
High psychological distress (K10 > 21)	15 (8–24)	7 (4–10)	10 (7–14)	7 (7–8)
Treated for anxiety	10 (5–18)	6 (3–10)	6 (3–9)	5 (5–6)
Treated for depression	12 (6–21)	8 (5–12)	7 (4–11)	7 (6–7)
Body mass index—obese	25 (16–35)	21 (16–26)	23 (18–28)	19 (18–20)

Notes Statistical comparisons results are in Supplementary file 4

These differences between the flood footprint areas suggest that the Lismore Town flood response may encounter elevated needs for mental health and self-care support.

4 Discussion

To our knowledge, our research is one of the few Australian studies to describe the social vulnerability of flood-affected rural populations derived from up-to-date census data and detailed cohort study data, in combination with flood event maps provided by government authorities. Other Australian flood studies have used census data at a town or district geographical level but not with flood event mapping (for example, Boon 2014).

Our wider study region of the Richmond-Tweed SA4, using 2016 census information, showed significantly greater social vulnerability when compared to the Greater Sydney area. This was most clearly demonstrated with the general summary measure of socio-economic disadvantage (SEIFA IRSD) where less than 4% of residents were in the least disadvantaged quintile compared to over 27% in the Sydney area. This was also evident with more older residents, residents living alone, Aboriginal and Torres Strait Islander people, residents in need of assistance, single-parent families all of which can have burdens in addition to those of an economic nature.

The extent of this disadvantage was even more pronounced in the flood footprints and differed by location. The degree of disadvantage for the 2017 Lismore Town Centre Flood footprint was especially high, with 82% of residents in the socio-economically lowest quintile compared to 47% and 60% in the other larger flood footprints. This 2017 Lismore Town Centre Flood area also had relatively high levels of other indicators of social vulnerability such as low income, low education, living in rented accommodation, single-parent families and Aboriginal and Torres Strait Islander people. Not all of these indicators are captured in the construction of the composite 2016 SEIFA IRSD measure, and it is important to understand the vulnerability differences over a multiplicity of economic and demographic factors.

Gender was not generally found to be associated with our flood-prone areas, in keeping with the findings of Kuhlicke et al. 2011. The young and the elderly have been identified as especially vulnerable age groups in times of flood (Bei et al. 2013; Fatemi et al. 2017), but in our flood areas children were not over-represented neither were the elderly in the Lismore flood areas.

It is known that flood risk is a significant predictor of both lower rental and sale prices of properties (Hirsch and Hahn 2018; Bin and Polasky 2004). The two Lismore flood areas both exhibited significantly higher rates of renting compared to the regional average; this in conjunction with lower-income levels can impact on housing security. In contrast, the Murwillumbah Region Flood area home ownership was higher so its residents may be less susceptible to this.

Rufat et al. (2015) and Zhong et al. (2018) highlight the impact of flooding on physical and mental health and mortality. The review by Stanke et al. 2012 indicated that flooding can exacerbate or provoke mental health problems. Our results using a cohort of older NSW residents residing in the North Coast (2006–2009) suggest that those in the flood-prone areas were already particularly susceptible to adverse mental health outcomes and were likely to be especially in need of mental health support after the disaster. This was particularly evident in the Lismore Town footprint with close to twice the rate of psychological distress, anxiety and depression than the wider study area.

The implications of this work for the level, type and distribution of disaster relief are clear. Disaster relief planners should incorporate the greater needs of the most disadvantaged people in disaster relief planning and also have a detailed knowledge of the patterns of susceptibility at a local level in order to deliver suitably targeted relief. One way to do this is for planners to conduct local studies. As Rufat et al. suggested, empirical case studies are needed to understand social vulnerability in the local context (Rufat et al. 2015). Our study is also an example of providing a localised report and analyses consistent with the Sendai Framework for Disaster Risk Reduction (UNISDR 2015b).

The results from this study show that it is not sufficient to assume the homogeneity of a region with respect to socio-demographic and economic susceptibility attributes when providing emergency flood-related responses. The need for context-specific and locality-specific research was confirmed in our study, even within the one region which showed increased vulnerability of flood-prone populations over and above the disadvantage faced by regional populations. Even between flood-affected areas in the region there was strong variability in the degree and pattern of vulnerability.

Particular attention should be paid to the socio-economic vulnerability of flood-prone areas because aspects of this were the strongest drivers of social vulnerability in this study. This study shows the potential for targeting socio-economic development to improve disaster-control infrastructure planning and so reduce human suffering from flood events (Hu et al. 2018).

4.1 Strengths and limitations

The major strength of this study is the examination of the local context in which vulnerability occurs, and we were able to demonstrate the high degree of variability among communities experiencing the same flood event.

The ABS 2016 census data was timely, collected only 7 months before to the flood event. In addition, the release of the SEIFA SES information occurred in March 2018, thus strengthening the data by having the most up-to-date population profiles.

We acknowledge the limitation of using modelled river height data for the 2017 flood event and the restricted nature of the flood maps, where not all known flood-affected locations in the region were included. The 1974 Lismore Region Flood footprint map derived from the mapping the 1974 flood event has acknowledged limitations due to the lack of historical information and limited technological resources when the map was constructed.

Availability and selection of appropriate maps are of vital importance in these types of studies. The 2017 flood maps provided by the Office of Environment and Heritage (2014) were generated to specifically model the 2017 flood event using recorded river heights and rainfall intensity but only for selected watersheds.

Using ABS Census data from the General Community profiles which were only available at an aggregated area basis does not enable the investigation of interactions between socio-demographic factors, as highlighted by Walker and Burningham (2011). (For example, different vulnerabilities experienced with combinations of age and gender, low-income people renting in flood-prone areas and so on.) Neither was our methodology able to assess the more dynamic process of vulnerability where people's vulnerability may change through all phases of the disaster cycle.

The temporal differential between 45 and Up participant baseline information (2006–2009) and the 2016 census data used in this paper is also acknowledged, as is the age restriction on the survey participants. However apart from age, the demographic

patterns remain similar for the study area and provide a unique understanding of the health and lifestyle differences for older residents in the flood footprints. These limitations should be taken into account when interpreting the results of this study.

Finally, any research needs to acknowledge the limitations imposed by the ecological fallacy: Aggregated data do not describe any individual or subpopulation. Indeed, the current work could be regarded as an exemplar of this; we show that a subpopulation (the flood affected) are far from being representative of the broader region. Several authors (Remo et al. 2016; Fekete 2012) point out that whatever the level of analysis, the data are likely to reflect heterogeneity in the degree and nature of susceptibility.

Despite the constraints described, the messages from these data come through clearly, and none of these limitations have the potential to fundamentally undermine the conclusions of this work.

5 Conclusion

We have demonstrated that detailed empirical case studies of this type are necessary to understand the local context for effective disaster planning.

This detailed case study established the extreme vulnerability of our flood-exposed populations, over and above the already highly vulnerable regional population. We demonstrated that the most disadvantaged socio-economic quintiles from the SEIFA IRSD were substantially over-represented in all flood footprints (Lismore Town Centre 82%, Murwillumbah Region 47% and Lismore Region 60%) compared to the wider Richmond-Tweed region (27%) and urban Sydney (16%). This is supported by ABS demographic and economic data as well as survey data on lifestyle and health including pre-existing mental health conditions.

The identification of the high level of socio-economic disadvantage in flood-affected rural areas highlights the importance of targeted disaster relief, given that the disaster-affected people in the study area had the fewest resources to recover effectively. In other words, those in this study at greatest risk of inundation tend to be those most susceptible to its effects.

This paper further demonstrated that information on socio-demographic vulnerability can be derived from available flood maps combined with government and census information.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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