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Original Contribution

Drought and Distress in Southeastern Australia

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Abstract: Droughts may increase the risk of mental health problems, but evidence suggests a complex story with some groups being vulnerable while others are not. Previous studies from Australia have found associations with suicide, depression and distress that vary by age, gender and remoteness. Understanding the effects of drought on mental health is important because drought is predicted to be more intense in some areas in the future. We investigated the associations between drought and distress in a survey of rural Australians by age, gender and farming status. We collected distress data using a survey of 5312 people from across the state of Victoria, Australia, in 2015. Respondents completed the Kessler 10 (K10) Psychological Distress Index, and demographic and general health data were collected. We linked a climatic drought index to the locality of residence of respondents. Associations between distress and drought were analyzed using multivariable regression models with interactions by age, gender and farming occupation. Parts of Victoria were in drought in 2015. Drought duration was associated with higher distress in younger rural women (aged 40–54: odds ratio 1.18 per inter-quartile range increase in drought duration) but not older rural women or men. This pattern did not vary between farmers and non-farmers. Drought was associated with increased distress, but this differed between subgroups. Our results suggest that supporting younger women may be particularly important, and understanding ways older Australian rural women cope may enable us to build adaptive capacity and resilience.

Keywords: Drought, Rainfall, Climate, Distress, Mental health

Introduction

Drought has been suspected to increase both physical and mental health problems through a range of possible pathways (Stanke et al. 2013; Vins et al. 2015). Throughout history, droughts have caused significant disruptions to communities worldwide, contributing to the decline of civilizations (McMichael 2017) and the recent civil war in Syria (Kelley et al. 2015). At an individual level, droughts have been associated with increased risk of suicide in Australian rural men (Hanigan et al. 2012) and distress in residents from rural Australian communities (O'Brien et al. 2014) and in farmers (Edwards et al. 2014). However, a cohort study of older Australian women found a lack of association between drought and depression (Powers et al. 2015), suggesting a complex pattern of vulnerability and mental health outcomes across subgroups.

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Models of climate change suggest that a number of countries will experience more widespread and frequent droughts this century (Dai 2012; Trenberth et al. 2014; Watts et al. 2017). Droughts are considered one of the major pathways by which climate change health risks will manifest and are of substantial concern (Berry et al. 2010; Clayton et al. 2015; McMichael et al. 2015).

Quantitative evidence on the different pathways through which drought may impact mental health remains limited. In a review of 82 studies, Vins et al. (2015) found that many papers (33, or 40%) focused on the economic effects of drought, including financial impact on farmers (Edwards et al. 2014). Other plausible pathways include impacts on mental health related to decreased physical health resulting from air pollution from drought-related bushfires and dust storms (Berman et al. 2017). There are also some qualitative studies of psychosocial pathways (Albrecht et al. 2007; Ellis and Albrecht 2017).

Perhaps the strongest evidence is provided by two papers linking suicide and drought from the state of New South Wales (NSW), Australia (Hanigan et al. 2012; Nicholls et al. 2006), which examined data across a long period. Suicide rates in the total population were found to be associated with inter-annual rainfall deficits between 1964 and 2001 (Nicholls et al. 2006).

Another study of NSW between 1970 and 2007 found increased risk of suicide for rural men during droughts, but an unexpected decreased risk of suicide in rural women in drought (especially pronounced among women aged 50-plus) (Hanigan et al. 2012). The finding was supported by a subsequent study that found a lack of any associations between depression and drought in a cohort of rural older women (N = 6664, age range 47–61) (Powers et al. 2015).

In this paper, we focus on nonspecific psychological distress and depression as measured by the Kessler 10 (K10) index (Kessler et al. 2002). The K10 is often used to measure distress, a form of mental illness characterized by feelings of anxiety, worry and fatigue (Andrews and Slade 2001); but has also been shown to identify depression (Kessler et al. 2003). Our focus on distress is particularly relevant because it is a useful indicator of the likelihood of having a range of mental health disorders without being specific to any one disorder (Furukawa et al. 2003; Kessler et al. 2010).

The K10 has also been shown to be a valid screening tool for the Australian population (Slade et al. 2011). It provides a useful population level and an 'early warning' measure of initial increases in distress that is possible to measure in a self-administered survey with low respondent burden (Cairney et al. 2007).

Exposure and vulnerability to drought may vary by subgroups more than just gender and age. The differences between farmers and non-farmers may be important because farmers are directly impacted through a broad range of potential pathways (e.g., economic, food security, psychosocial or physical health factors), whereas non-farmers may only have some of those pathways. An analysis of a survey with respondents from across Australia in 2007 found that drought had a negative mental health impact on farmers but not on non-agricultural rural people (Edwards et al. 2014).

Arguments for comparing genders include that there are well-known substantial gendered differences in incidence of distress in general, as well as in incidence of distress in response to stressful events (Alston 2012). There are similar arguments for comparing distress levels across age groups, with evidence that distress incidence varies by age and gender (Crnek-Georgeson et al. 2017). Our study controls for these factors while assessing the impact of drought exposures, which was not done by the previous studies.

In this paper, we investigated whether drought was associated with distress for specific subgroups by gender, age and farming status in a survey of rural people from southeastern Australia.

Methods

Study Region

The southeast Australian state of Victoria was selected as our study region because in 2015 this region had some areas which were in severe drought and some that were not. The rainfall in the preceding years had also been significantly reduced from the average climate which led the Victorian Government to announce a drought support package in November 2015 that allocated AUD$27 million to assist drought-affected farmers, businesses and communities (Victorian Department of Economic Development, Jobs, Transport and Resources 2016).

Survey Coverage, Design and Participants

We collected distress data using a survey questionnaire we developed seeking to understand drought and related impacts on well-being of adults living in rural Australia. Rural

is defined here as all areas outside Australia's big cities of Sydney, Melbourne, Adelaide, Brisbane, Perth and Canberra. We collected data in spring 2015 (October–November) from across Australia, but the state of Victoria was intensively sampled giving excellent coverage across the whole state (Schirmer et al. 2016). There was a spatial contrast in drought exposure across the areas within Victoria: Some were drought afflicted at the time, whereas other areas where not, so we restricted our study to respondents from this state.

We collected detailed information on occupation to focus on any difference between farmers and non-farmers. We focus only on those actively engaged in managing a farm, rather than other members of the household, to hone in on the specificity of any effects on farmers well-being. The definition of a farmer here is a person who is directly involved in managing a farm. This includes those who both own and manage a farm, those who manage a farm on behalf of an owner, and both paid and unpaid farm managers.

Two platforms (online and paper) were used to collect data, and participants were recruited using a variety of methods (including letters to a random sample of farmers using the FarmBase database and flyers delivered to every letterbox in designated postal areas) (Schirmer et al. 2016). Not all people who manage a farm identify or define themselves as a farmer: because of this, the online survey included several screening questions that were used to identify whether a person was involved in managing a farm and therefore whether their responses were analyzed.

The resultant study population was intentionally biased to overrepresent farmers (as this group was intended to be specifically analyzed), and there was an unintentional sample bias in the overrepresentation of older women, and underrepresentation of younger men. The survey was approved by the University of Canberra Human Research Ethics Committee, protocol number 12-186, and informed consent was obtained from all survey participants.

Locational information was collected by asking survey respondents to name the town or locality they lived in (a locality is a term used in Australia which is equivalent to a small village), or, if they lived on a rural property, the town or locality they lived closest to. Details of the geographical data processing used to attach spatial information to the survey are presented in supplementary appendix.

Measures

Distress

The K10 scale is a measure of nonspecific psychological distress (Kessler et al. 2002). Participants responded to ten items reflecting how they felt in the past 4 weeks: (1) tired out for no good reason; (2) nervous; (3) so nervous that nothing could calm them down; 4) hopeless; (5) restless or fidgety; (6) so restless they could not sit still; (7) depressed; (8) that everything was an effort; (9) so sad that nothing could cheer them up; and (10) worthless. Responses were text descriptors for the following five points: (1) none of the time; (2) a little of the time; (3) some of the time; (4) most of the time; and (5) all of the time. For any respondents with one item missing from the K10, a mean from the remaining variables was calculated to impute that value. If more than two items were missing, the response was excluded. Real and calculated scores were then summed to create a final score. The summed score ranges from 10 to 50. We also classified respondents as 'distressed' or 'not distressed' based on other literature (Australian Bureau of Statistics 2007) that classified people with K10 values of 10–15 as having low levels of distress, 16–21 as moderate levels of distress, 22–29 as high levels of distress and 30–50 as very high levels of distress (Australian Bureau of Statistics 2007).

Drought

We used the Hutchinson Drought Severity Index (HDSI) because it reflects government declared 'agricultural' droughts in Australia (Smith et al. 1992). There are two HDSI methods used to track the dryness of different places: the duration and intensity. Details of the HDSI definition and validation are presented in supplementary appendix.

We used HDSI drought exposures for the month of September 2015 to represent the time for which our survey data were derived. We used monthly rainfall data from the Australian Bureau of Meteorology to compute six-monthly seasonal rainfall indicators as inputs to compute the HDSI indices for 25 × 25 km squares across Australia for the 1900–2015 period (Hanigan 2012; Hanigan et al. 2012). We then assigned these as drought exposure estimates to the residential location of each survey respondent.

We first used the HDSI (duration and intensity) indices as continuous measures of drought (i.e., length of time person's residential area had been in dry conditions) in regression models that aim to identify associations be-

tween distress and drought. Second, we also transformed each continuous score into a binary variable to summarize data as 'in drought' or 'not in drought,' for descriptive statistics.

Effect Modifiers

Several other risk factors might act as effect modifiers. In our analysis, we included interaction terms of drought with age, gender and farming. Age groups were chosen a priori and were defined as 18–39, 40–54, 55–64 and 65-plus. We considered groups 'under 65' to be the younger and mid-aged people, and 'over 65' to be the older age group, based on the age at which Australians generally retire. This age classification was chosen as it is also broadly similar to the age cohort examined by Powers et al. (2015) who found no association between drought and distress in older women (aged 47–61). A farmer was defined in this study as a person directly involved in managing a farm. This includes those who both own and manage a farm, those who manage a farm on behalf of an owner, and both paid and unpaid farm managers. We define a farm as rural land managed for commercial return from production of crops or livestock.

Other Covariates

In our models, we included additional covariates on general health, demographics and remoteness because they may explain some variability in distress and should reduce the standard errors on our main exposures of interest.

The general health score was self-reported by respondents who were asked how they would rate their general health. They could select from the text descriptors (1) excellent; (2) very good; (3) good; (4) fair; or (5) poor. This simple measure has been shown in previous studies to have high validity as a single-item measure of general health (DeSalvo et al. 2006). Poor health in our analysis was combined from responses (4) fair and (5) poor. This dichotomization of the 5-point scale to a version of excellent, very good, or good versus fair or poor is frequently used to increase the reliability of self-reported health because it is known that the number of levels in a variable influences its reliability (Zajacova and Dowd 2011).

We also included the demographic factors for educational attainment and adult cohabitation status. Level of educational attainment was categorized as high school (defined as completing year 12 at high school), certificate/university or none of these. Cohabitation status was classified as either living in a couple or single.

The remoteness of each location was defined using the Australian Bureau of Statistics Remoteness Areas from 2011 (Australian Bureau of Statistics 2011). The Accessibility/Remoteness Index of Australia was used to classify each respondent's area of residence as 'major city,' 'inner regional,' 'outer regional' or 'remote'.

Statistical Analysis

The main explanatory variables were the HDSI drought indicators, which were log-transformed due to skewness. All models were adjusted for general health, demographic and remoteness variables. We included a spatial trend (fitted to the centroid coordinates of each locality) to account for potential clustering and residual spatial autocorrelation (Wood 2006).

Model 1 addressed the question of whether any association between increasing distress and drought varies by gender. Model 2 refined the question to ask if risk of distress due to drought varied by both age and gender. Model 3 explored whether farming men or women have increased risk of distress during drought periods, while Model 4 assessed if associations among farming men or women vary by age group. Standard model checking and diagnostics were performed. All analyses were conducted in R version 3.2.5 (http://www.r-project.org). Further information is supplied in supplementary appendix.

Our modeling strategy was to first explore the log-transformed K10 scores as a continuous outcome measure and test for nonlinear associations with the drought indices. We used a log-transformed K10 variable to satisfy the assumptions of normality and homoscedasticity. The Generalized Additive Model (GAM) procedure from the R package 'MGCV' (version 1.8-12) was used to fit penalized regression splines to test for nonlinearity. The difference in Bayesian information criterion (BIC) was used to assess significance with a threshold of six-point difference between BIC to define a strong evidence for an improvement (Raftery 1995).

We then used additional models to explore these associations by fitting logistic models using the binary outcome variable as 'distressed' (K10 score: 16–50) versus 'not distressed' (K10 score: 0–15) regressed on the continuous drought index scores because analysis of drought duration as a continuous variable allows investigation of

any evidence for a dose–response association. All models included a spatial trend to control for spatial autocorrelation.

Results

There was a possible study population of 5411 respondents from Victoria; however, around 2% (99) had missing data for K10, thus leaving 5312 responses for analysis. The observed distribution of the K10 distress scores was highly skewed, with most respondents having low scores (less distress). In aggregate, the mean K10 was 15.9 [95% confidence intervals (CI) 15.7–16.0], the median was 14 (2.5% = 10, 97.5% = 33) and the inter-quartile range was 6.

The spatial distribution of survey respondents is shown in Fig. 1, overlaid by Australian Bureau of Statistics Statistical Area 2 (SA2) boundaries, and shows that respondents came from all areas of the state. The population distribution is also indicated by the size of the SA2s. Because larger SA2s are used for unpopulated areas such as deserts and mountains, the density of respondents was lowest in those relatively unpopulated areas. There were also no respondents for some areas that are largely national park and ski resorts in the central-eastern area.

Descriptive statistics of the distributions of respondents between drought and non-drought are shown in Table 1, along with the mean K10 scores and 95% CI. In most subgroups, the respondents who were currently in drought had higher distress (mean K10 scores). Drought was common in the west and center of Victoria in 2015; it was not in the east (Fig. 2). Across all respondents the mean drought duration that had been experienced up until September 2015 was 4.7 months (median = 3, inter-quartile range = 3, minimum = 0, 2.5% = 0, 97.5% = 16,

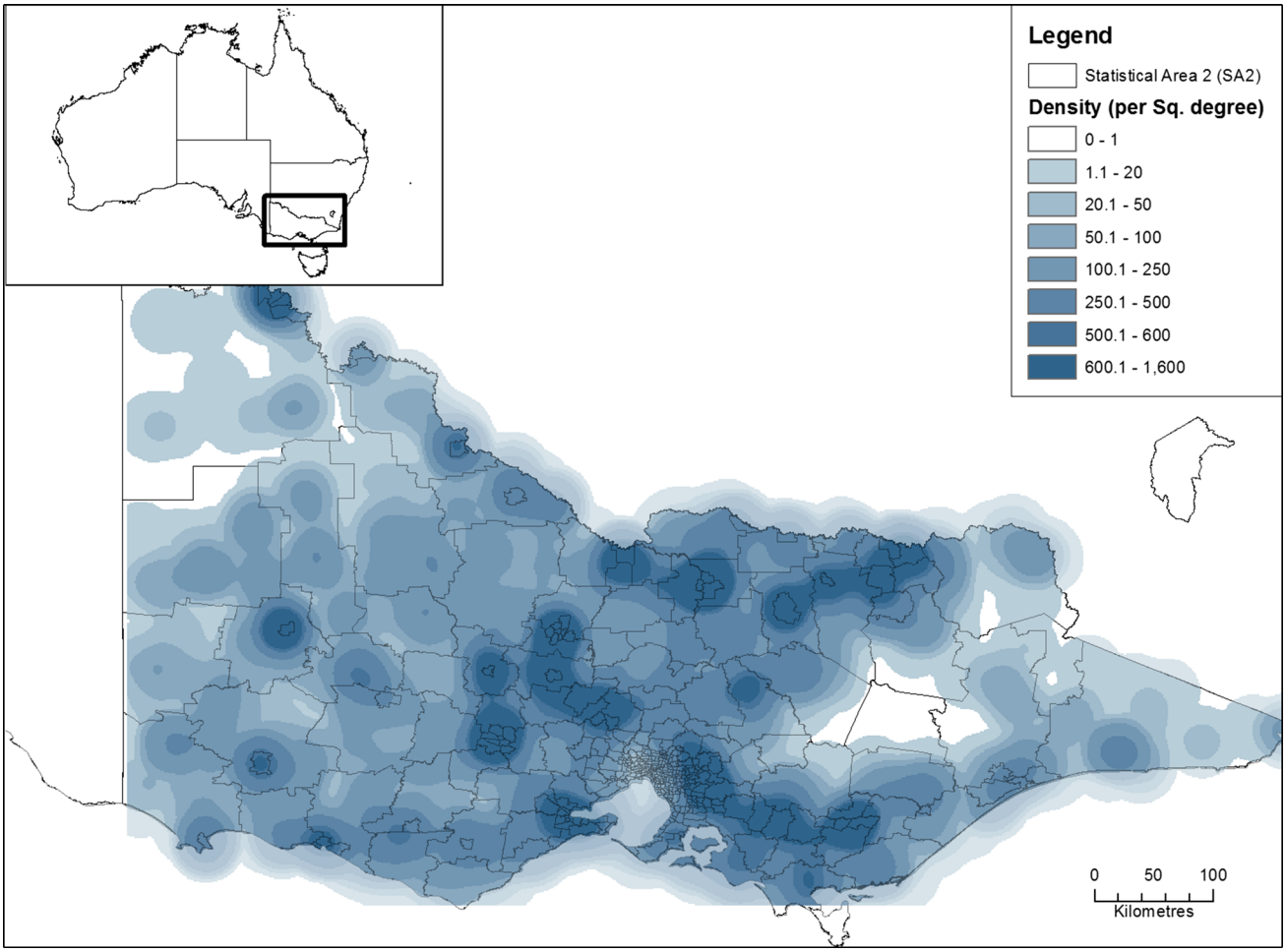

Fig. 1. Spatial distribution of respondents represented as a kernel density surface based on the centroid coordinates of localities, overlain by Statistical Area 2 (SA2) census boundaries.

Table 1. Characteristics of Regional Australians by Drought and K10 Distress Scores.

	Not in drought	Drought	*N*	K10 mean (95% CI) Not in drought	K10 mean (95% CI) Drought
All					
Total	3700	1612	5312	15.7 (15.5, 15.9)	16.2 (15.9, 16.5)
Distressed					
Distressed	1394	651	2045	21.6 (21.3, 21.9)	22.1 (21.6, 22.6)
Not distressed	2306	961	3267	12.1 (12.1, 12.2)	12.2 (12.1, 12.3)
Remoteness area					
Major city	237	78	315	15.5 (14.7, 16.3)	16.8 (15.2, 18.3)
Inner regional	2391	1056	3447	15.7 (15.5, 15.9)	16.2 (15.9, 16.6)
Outer regional	1006	478	1484	15.7 (15.3, 16.1)	16.1 (15.5, 16.6)
Remote	58	0	58	17.0 (15.7, 18.4)	–
Missing	8	0	8		
Education					
None of these	728	326	1054	16.1 (15.7, 16.6)	16.1 (15.5, 16.8)
High school	454	242	696	15.8 (15.3, 16.4)	16.5 (15.7, 17.4)
Certificate/degree	2465	1032	3497	15.6 (15.3, 15.8)	16.2 (15.8, 16.6)
Missing	53	12	65		
Household					
Couple	2718	1155	3873	15.3 (15.1, 15.5)	15.7 (15.4, 16.1)
Single	963	452	1415	16.9 (16.4, 17.3)	17.5 (16.8, 18.2)
Missing	19	5	24		
General health					
Good health	3111	1332	4443	14.7 (14.5, 14.9)	15.2 (14.9, 15.5)
Poor health	582	277	859	21.2 (20.6, 21.9)	20.9 (20.0, 21.9)
Missing	7	3	10		
Age					
18–39	397	210	607	17.7 (17.0, 18.4)	18.0 (17.2, 18.9)
40–54	974	406	1380	16.6 (16.2, 17.0)	17.3 (16.6, 17.9)
55–64	1102	462	1564	15.5 (15.1, 15.8)	16.3 (15.7, 16.9)
65-plus	1192	522	1714	14.4 (14.2, 14.7)	14.5 (14.1, 14.9)
Missing	35	12	47		
Gender					
Female	2145	918	3063	16.0 (15.8, 16.3)	16.6 (16.2, 17.0)
Male	1527	678	2205	15.2 (14.9, 15.5)	15.6 (15.1, 16.0)
Missing	28	16	44		
Farmer/non-farmer					
Farmer	1219	468	1687	15.2 (14.9, 15.5)	15.3 (14.8, 15.8)
Non-farmer	2457	1135	3592	16.0 (15.7, 16.2)	16.6 (16.2, 17.0)
Missing	24	9	33		

maximum = 21). The correlation between the logged K10 and logged drought duration variables was low (Spearman's rho = 0.028). Table 2 and Fig. 3 show the pattern of mean K10 distress scores by age and gender. There was a higher mean distress score in the drought-exposed younger women (below 64 years old), but not in drought-exposed older women (65-plus) or men.

In all GAM models, the nonlinear curves were not significant when tested using the difference in BIC against linear models. Therefore, we fit linear response models for

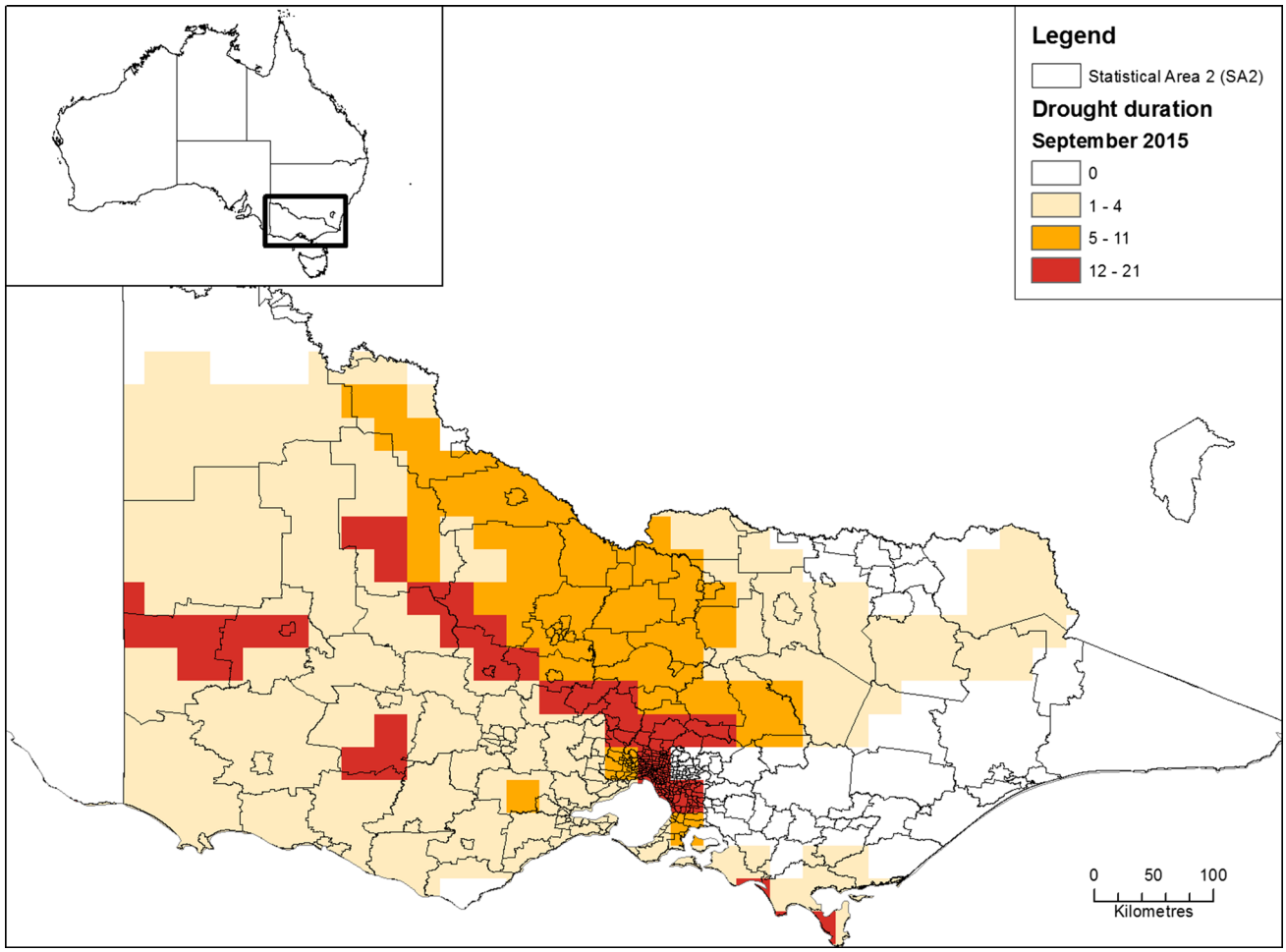

Fig. 2. Hutchinson Drought Severity Index (HDSI) estimated drought duration (number of months in drought) in September 2015.

Table 2. Differences Between Mean K10 Distress Scores and 95% Confidence Intervals (CI) Between Those in Drought and Not in Drought, by Age and Gender.

	Not in drought	Drought	*N*	K10 mean (95% CI) Not in drought	K10 mean (95% CI) Drought
Females					
18–39	306	167	473	17.5 (16.7, 18.3)	18.1 (17.1, 19.1)
40–54	706	278	984	16.6 (16.1, 17.1)	17.6 (16.8, 18.4)
55–64	632	253	885	15.6 (15.2, 16.0)	16.8 (15.9, 17.7)
65-plus	486	215	701	14.6 (14.2, 15.1)	13.9 (13.3, 14.5)
Males					
18–39	91	43	134	18.4 (16.9, 19.8)	17.9 (15.8, 19.9)
40–54	265	124	389	16.5 (15.7, 17.3)	16.4 (15.1, 17.7)
55–64	466	207	673	15.3 (14.8, 15.8)	15.6 (14.8, 16.4)
65-plus	699	302	1001	14.3 (13.9, 14.6)	14.9 (14.3, 15.5)
Total	3651	1589	5240		

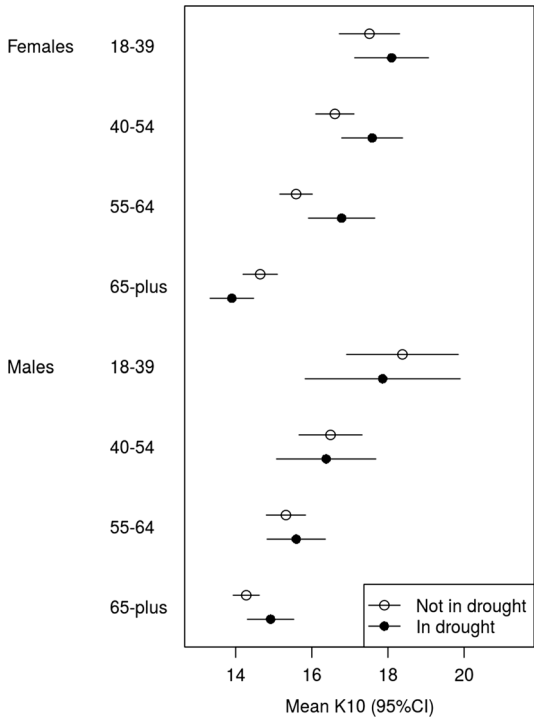

Fig. 3. Differences between mean K10 distress scores and 95% confidence intervals (CI) between those in drought and not in drought, by age and gender.

all drought/subgroup interactions. See Table S1 in supplementary appendix for our diagnostics of the nonlinear models. In Table 3, the coefficients, standard errors (SE) and *P* values are reported for Model 1 (drought by gender) and Model 2 (drought by gender by age). Model 1 showed an association between drought and distress in women but not in men. In Model 2, the younger women aged between 40 and 64 showed increased distress during droughts, but this was not in older women.

Table 4 describes Model 3 (drought by gender by farmer status) and Model 4 (drought by gender by farmer status by age). These models showed that the association between distress and drought in younger women but not older women or men appeared in both farmer and non-farmer subpopulations (although in farming women aged 40–54, this was only borderline significant at $P = 0.06$).

Table 5 displays odds ratio (ORs) and 95% CI for logistic regressions using binary distressed/non-distressed as the outcome. Computed ORs for the drought are expressed as the increased odds of being distressed associated with an increase in the logged drought duration predictor equivalent to one inter-quartile range (IQR) change (while holding all other variables constant). In Model 2, ORs for the interaction subgroup of females aged 40–54 suggested that for an IQR rise in the logged drought duration index there would be an expected increased odds of being distressed of 1.18 (1.04, 1.35 95% CI). The IQR of logged drought count was equivalent to one month of drought duration (when back-transformed).

Results using the HDSI intensity measure were similar and are presented in supplementary appendix.

Discussion

There was generally a slightly higher average distress level in all subgroups who were in drought compared with those not in drought shown in our descriptive statistics. In our regression modeling, we found statistically significant associations between distress and drought duration in younger and mid-aged rural women (especially those aged 40–54: odds ratio 1.18 per IQR change in drought duration). This association was observed regardless of whether they were in farming occupations or not. We found a lack of association between drought and distress in older rural women (65-plus) or men, and the lack of association did not vary by farmer/non-farmer status.

The association between drought and distress has been investigated in previous papers, with a special focus on farming and rural people. Two studies that used data from a major longitudinal Australian survey found that drought was associated with increased distress for people living in rural areas (Friel et al. 2014; O'Brien et al. 2014). Those authors suggested this may be because of the high proportion of rural residents who are farmers or people employed in agricultural industries. In a study that used an alternative measure of drought that was self-reported by others in the same area (based on the assessment of respondents to a question about whether the area in which they live is experiencing drought) Edwards et al. (2014) estimated a negative impact on the mental health of farmers and farm workers, but little effect on those who were in non-agricultural employment. Our results, however, do not find the association with drought differed in the levels of distress of farmers or non-farmers in the sample population we surveyed, with the objective climatic drought index we used.

Our findings shed light on previous counterintuitive conclusions of decreased risk of suicide in women during droughts (Hanigan et al. 2012) and a lack of association with depression in older women (Powers et al. 2015). The findings of two previous papers (Hanigan et al. 2012;

Table 3. Model 1 (Drought by Gender) and Model 2 (Drought by Gender by Age). Referent Level Shown for Categorical Covariables.

Model 1				Model 2			
	Coef.	SE	*P* value		Coef.	SE	*P* value
log(Drought) × Male	0.00	0.01	0.82	log(Drought) × Male-18–39	0.01	0.02	0.58
log(Drought) × Female	0.02	0.01	0.02	log(Drought) × Male-40–54	0.00	0.02	0.90
				log(Drought) × Male-55–64	0.00	0.01	0.75
				log(Drought) × Male-65-plus	0.00	0.01	0.97
				log(Drought) × Female-18–39	0.02	0.02	0.35
				log(Drought) × Female-40–54	0.04	0.01	<0.01
				log(Drought) × Female-55–64	0.03	0.01	0.05
				log(Drought) × Female-65-plus	− 0.01	0.01	0.68
Major city	0.00	–	–	Major city	0.00	–	–
Inner regional	− 0.02	0.02	0.33	Inner regional	− 0.02	0.02	0.37
Outer regional	− 0.03	0.03	0.24	Outer regional	− 0.03	0.03	0.26
Remote	0.05	0.05	0.31	Remote	0.05	0.05	0.30
Education (none of these)	0.00	–	–	Education (none of these)	0.00	–	–
High school	0.00	0.01	0.83	High school	0.00	0.01	0.74
Certificate/degree	− 0.03	0.01	< 0.01	Certificate/degree	− 0.03	0.01	< 0.01
Couple	0.00	–	–	Couple	0.00	–	–
Single	0.06	0.01	< 0.01	Single	0.06	0.01	< 0.01
Good health	0.00	–	–	Good health	0.00	–	–
Poor health	0.33	0.01	< 0.01	Poor health	0.33	0.01	< 0.01
18–39	0.00	–	–	18–39	0.00	–	–
40–54	− 0.08	0.01	< 0.01	40–54	− 0.09	0.03	< 0.01
55–64	− 0.14	0.01	< 0.01	55–64	− 0.15	0.03	< 0.01
65-plus	− 0.21	0.01	< 0.01	65-plus	− 0.20	0.03	< 0.01
Female	0.00	–	–	Female	0.00	–	–
Male	0.02	0.02	0.27	Male	0.01	0.02	0.46
Farmer	0.00	–	–	Farmer	0.00	–	–
Non-farmer	0.02	0.01	0.02	Non-farmer	0.02	0.01	0.02

Powers et al. 2015) suggest that the mental health of rural women appears to be less affected by drought than that of rural men. This was contrary to assumptions made by many commentators of the mental health impacts of drought, who often postulated a uniform detrimental dose–response association with drought across all age and gender groups (Berry et al. 2010; Friel et al. 2014; O'Brien et al. 2014). Our findings from this current paper add new insights to the literature, especially the results of Model 2 which showed an increased risk in younger women but lack of association in older women.

The balance of evidence from the findings so far suggests that older rural women are more resilient to drought than younger women. A previous study from New South Wales (1970–2007) showed an increased relative risk of suicide for 10- to 49-year-old rural men with increasing drought, but a significant decrease in risk for women (of any age, but especially older women) (Hanigan et al. 2012). Identifying factors influencing this resilience and their coping mechanisms could inform the design of preventive interventions for drought-affected communities. Other evidence suggests that women have higher levels of social support and greater resilience in general than men (Alston 2012), and so further research is needed on factors that may explain older rural Australian women's ability to cope with drought.

It is possible that older Australian rural women are more experienced with a range of adverse conditions, including drought, than younger women and have likely developed better coping mechanisms. It is notable that

Table 4. Model 3 (Drought by Gender by Farmer/Non-farmer) and Model 4 (Drought by Gender by Farmer by Age). Referent Not Shown.

Model 3				Model 4			
	Coef.	SE	*P* value		Coef.	SE	*P* value
log(Drought) × Male-Farmer	0.00	0.01	0.92	log(Drought) × Male-18–39-Farmer	0.02	0.03	0.57
log(Drought) × Male-Non-farmer	0.00	0.01	0.80	log(Drought) × Male-40–54-Farmer	0.01	0.02	0.62
log(Drought) × Female-Farmer	0.02	0.02	0.13	log(Drought) × Male-55–64-Farmer	0.00	0.02	0.98
log(Drought) × Female-Non-farmer	0.02	0.01	0.03	log(Drought) × Male-65plus-Farmer	0.00	0.02	0.87
				log(Drought) × Male-18–39-Non-farmer	0.01	0.02	0.68
				log(Drought) × Male-40–54-Non-farmer	− 0.01	0.02	0.53
				log(Drought) × Male-55–64-Non-farmer	0.01	0.02	0.57
				log(Drought) × Male-65plus-Non-farmer	0.00	0.01	0.82
				log(Drought) × Female-18–39-Farmer	0.00	0.03	0.97
				log(Drought) × Female-40–54-Farmer	0.04	0.02	0.06
				log(Drought) × Female-55–64-Farmer	0.02	0.02	0.22
				log(Drought) × Female-65plus-Farmer	0.01	0.02	0.75
				log(Drought) × Female-18–39-Non-farmer	0.02	0.02	0.30
				log(Drought) × Female-40–54-Non-farmer	0.04	0.01	< 0.01
				log(Drought) × Female-55–64-Non-farmer	0.03	0.01	0.05
				log(Drought) × Female-65plus-Non-farmer	− 0.01	0.01	0.53
Inner regional	− 0.02	0.02	0.33	Inner regional	− 0.02	0.02	0.37
Outer regional	− 0.03	0.03	0.24	Outer regional	− 0.03	0.03	0.26
Remote	0.05	0.05	0.31	Remote	0.05	0.05	0.30
High school	0.00	0.01	0.82	High school	0.00	0.01	0.74
Certificate/degree	− 0.03	0.01	< 0.01	Certificate/degree	− 0.03	0.01	< 0.01
Single	0.06	0.01	< 0.01	Single	0.06	0.01	< 0.01
Poor health	0.33	0.01	< 0.01	Poor health	0.33	0.01	< 0.01
40–54	− 0.08	0.01	< 0.01	40–54	− 0.10	0.03	< 0.01
55–64	− 0.14	0.01	< 0.01	55–64	− 0.15	0.03	< 0.01
65-plus	− 0.21	0.01	< 0.01	65-plus	− 0.20	0.03	< 0.01
Male	0.02	0.02	0.28	Male	0.01	0.02	0.51
Non-farmer	0.02	0.02	0.27	Non-farmer	0.02	0.02	0.29

lifestyles in Australia have changed dramatically over the last century, especially for rural people. The older women in our sample grew up in a time when rural incomes where lower and more variable, and this meant that many children experienced shortages. This may mean that as adults these women are more able to cope with the chronic nature of drought without suffering a mental health problem (Powers et al. 2015). The threshold of mental health impact in this group may therefore be higher than for younger women.

Another aspect of the lifestyles of older Australian rural women that may influence their ability to cope with drought is their role in volunteering and informal social support systems in their communities (Alston 2012). Alternately, it might also be that younger rural women have a range of family- and financial-related stressors that can exacerbate drought impacts.

The current study has several strengths. First, we had a large sample size who completed a survey that was specifically designed to measure several risk factors for well-being and mental health in rural Australians such as drought. The second strength was the HDSI climatic indexes of drought, which were calculated using more than one century of rainfall data, and validated against government drought declarations. This use of climate data allowed for objective identification of drought events for our study and avoids

Table 5. Binary Distressed (K10 > 15) Outcome Version of Model 1 (Drought by Gender) and Model 2 (Drought by Gender by Age). Odds Ratios Expressed as an Estimate per Inter-Quartile Range (IQR) Rise in the Predictor. Referent Not Shown.

Model 1 (Distressed)					Model 2 (Distressed)				
	Odds Ratio	Coef.	SE	*P* value		Odds Ratio	Coef.	SE	*P* value
log(Drought) × Male	1.02 (0.87, 1.20)	0.02	0.08	0.82	log(Drought) × Male-18–39	1.10 (0.89, 1.36)	0.14	0.16	0.39
log(Drought) × Female	1.14 (1.00, 1.32)	0.14	0.07	0.06	log(Drought) × Male-40–54	0.98 (0.83, 1.15)	− 0.03	0.12	0.81
					log(Drought) × Male-55–64	1.04 (0.90, 1.20)	0.06	0.11	0.61
					log(Drought) × Male-65-plus	0.99 (0.86, 1.13)	− 0.02	0.10	0.84
					log(Drought) × Female-18–39	1.13 (0.96, 1.33)	0.18	0.12	0.15
					log(Drought) × Female-40–54	1.18 (1.04, 1.35)	0.24	0.09	< 0.01
					log(Drought) × Female-55–64	1.08 (0.95, 1.24)	0.12	0.10	0.23
					log(Drought) × Female-65-plus	0.95 (0.82, 1.10)	− 0.08	0.11	0.48
Inner regional		− 0.08	0.16	0.62	Inner regional		− 0.06	0.16	0.69
Outer regional		− 0.06	0.20	0.76	Outer regional		− 0.05	0.20	0.81
Remote		0.59	0.37	0.11	Remote		0.60	0.37	0.11
High school		0.04	0.11	0.74	High school		0.03	0.11	0.79
Certificate/degree		− 0.18	0.08	0.03	Certificate/degree		− 0.18	0.08	0.03
Single		0.29	0.07	< 0.01	Single		0.30	0.07	< 0.01
Poor health		1.71	0.09	< 0.01	Poor health		1.72	0.09	< 0.01
40–54		− 0.41	0.10	< 0.01	40–54		− 0.42	0.22	0.05
55–64		− 0.73	0.10	< 0.01	55–64		− 0.65	0.22	< 0.01
65-plus		− 1.10	0.11	< 0.01	65-plus		− 0.84	0.22	< 0.01
Male		0.12	0.14	0.37	Male		0.06	0.14	0.67
Non-farmer		0.07	0.07	0.34	Non-farmer		0.07	0.07	0.36

potential bias from using self-reported drought as other studies have done (Edwards et al. 2014). Third, the comprehensive nature of the survey also allowed socio-demographic, geographic and health indicators of differential vulnerability to be taken into account.

A limitation of this study is that the survey sample may not be representative of the general Australian rural population, specifically older rural women were overrepresented and young rural men were underrepresented. A particularly high proportion of rural women with strong links to farming communities responded to the survey. Although broadly representative of women of the same age in the Australian population, there was some overrepresentation of more educated women. As a result, participants would be expected to have better mental health than general rural Australian women of the same age.

One of the possible reasons we did not observe a significant association between distress in young men in drought may relate to our relatively small sample size of young men. The numbers of young men in the sample are much smaller than the sample of young women, and so our study can only report on statistically significant differences based on the sample size available. These limitations do not detract from our interpretation of the associations observed in the larger sample of young women, or the importance of these results.

These findings are generalizable to other similar regions of Australia, and other regions around the world, where these subpopulation are found. Scenario-based climate change models suggest that many highly populated areas in a number of countries will experience more widespread and frequent droughts in the future. One study estimated that an additional 1.4 billion drought exposure events will occur globally by the end of the century (Watts et al. 2015).

Conclusions

Evidence is mounting that mental health problems in older Australian women may not be affected by drought. In this study, drought was estimated to have negative impact on mental health in younger women but not in older women, and this pattern did not differ by farming status. There are lessons to be learned from Australian rural women that may be used to help others to adapt to and cope with the adverse effects of drought.

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Compliance with Ethical Standards

Conflict of interest We declare no competing interests.

Ethics Committee Approval The survey was approved by the University of Canberra Human Research Ethics Committee, Protocol Number 12-186, and informed consent was obtained from all survey participants.

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