Social and health factors influence self-reported evacuation intentions in the wildfire-prone island of Tasmania, Australia

Sharon L. Campbell [a, *], Grant J. Williamson [b], Fay H. Johnston [a, c], David M.J.S. Bowman [b]

[a] *Menzies Institute for Medical Research, University of Tasmania, Liverpool St, Hobart, Tasmania, Australia*
[b] *Fire Centre, School of Natural Sciences, College of Science and Engineering, University of Tasmania, College Rd, Sandy Bay, Tasmania, Australia*
[c] *Public Health Services, Department of Health, Tasmania, PO Box 125, Hobart, Tasmania, 7001, Australia*

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ABSTRACT

Background: Personal decisions regarding evacuation to a safer place in response to the threat of wildfire have multiple social and cultural influences. However, little is understood about the role of an individual's health in shaping these decisions. Aim: To investigate associations between self-reported sociodemographic and health-related variables and wildfire evacuation intentions.
Methods: We used data collected in the 2016 Tasmanian Population Health Survey and implemented log binomial regression modelling to characterise associations between variables, including overall health status, presence of a chronic medical condition, age group, sex, educational attainment, employment status, financial security, and intention to leave during a wildfire threat.
Results: Females were significantly more likely than males to report an intention to leave (RR = 1.52, 95 % CI [1.40–1.66]), as were those with higher versus lower educational attainment (RR = 1.02, 95 % CI [1.00–1.03]), and those with a diagnosis of depression/anxiety (RR = 1.07, 95 % CI [1.00–1.15]) compared to those without. When stratified by sex, significant associations with intention to leave and asthma and higher educational attainment were observed in males (asthma: RR = 1.28, 95 % CI [1.04–1.57]; educational attainment RR = 1.05, 95 % CI [1.01–1.09]), while the association with anxiety/depression was imprecisely elevated for females (RR = 1.08, 95 % CI [1.00–1.16]). For males only, the presence of a chronic condition was significantly associated with an intention to stay (RR = 0.78, 95 % CI [0.62–0.99]).
Conclusion: Sex, educational attainment, and the presence of asthma and depression/anxiety influenced evacuation intentions for residents in our study. Such social, demographic and health differences should be considered in planning communication and messaging to residents in fire-prone areas.

1. Introduction

Wildfires are increasing in frequency and intensity across a greater range of locations globally, likely as a result of a changing climate [1]. Wildfire risks are driven by a combination of increased air temperature causing more days of extreme heat, increased arid-

ity, drought and longer fire seasons [2]. Wildfires present substantial social, ecological and economic impacts to affected regions [3,4], with a greater number of people living at the interface between populated urban settlements, and large tracts of undeveloped and fire-prone vegetation [5]. As a consequence of these overlapping dynamics, evacuation and adaptation strategies are becoming a pressing issue for local, regional and national governments and at-risk communities, resulting in individuals being required to make plans in response to the threat of wildfires.

In the event of a dangerous wildfire, individuals must either evacuate to a safer area or shelter in place – approaches that have considerable variability amongst nations. In Australia, the current Australian Fire Danger Rating System has graduated advisories for community response to wildfires, where the highest level of advice is to leave an area at risk of fire in response to forecast 'catastrophic' fire weather conditions that would promote uncontrollably intense wildfires, commonly known as 'leave early' [6]. An enquiry into the 2009 Black Saturday wildfires in Victoria found that 173 people died, 113 of which died inside their homes attempting to defend their property in accordance with the official advice of the time to 'prepare, stay and defend or leave early', commonly known as 'stay or go' [7–9]. The loss of life at this event resulted in a changed set of policies and advice to recommend leaving areas early to avoid exposure to catastrophic wildfire risk. Such voluntarily, self-organised and temporary mass evacuation differs markedly from other wildfire-prone jurisdictions such as Canada and the United States, where mandatory, government organised evacuation is the norm [5]. Therefore, essential to making an informed and safe decision, Australian residents must have a greater understanding of their personal and wildfire risk, and higher levels of situational awareness than residents in jurisdictions favouring mandated evacuations. Furthermore, early evacuation has been found to be of net economic benefit when compared to other risk mitigation strategies, including prescribed burning and home defence systems [10].

How individuals intend to respond to a wildfire threat, including whether they will self-evacuate in response to catastrophic fire weather, is key to understanding the likely effectiveness of the current Australian advice of 'leave early'. Further, such knowledge is a prerequisite to formulating effective, targeted policy and communications strategies to shape appropriate responses to the risk of wildfire. For example, it has been shown that although communities can accurately assess the risk of wildfire, there is a mismatch with wildfire preparation, signalling more effective community engagement and education is needed to close the 'knowing-doing' gap [11]. In this context, it is essential for policy makers to understand which factors influence communities and individuals when they are making decisions and responding to wildfire risk.

Research investigating factors associated with evacuation intentions during disasters is limited, with a small number of studies examining hurricanes [12–14], floods [15] and earthquakes [16]. Specific to wildfire disaster, the few studies undertaken in Australia and North America have shown that a decision to leave (or not) may be influenced by a complex mix of social, cultural and environmental factors. These include but are not limited to gender [17–19], political affiliation [18], pet and livestock ownership [18], preparedness actions [8,19,20], household composition [19], wildfire risk perception [20], previous experience with and knowledge of wildfires [19] and residence location [8] (noting that McLennan et al. [19] investigated actions undertaken during an event, rather than pre-event leave intentions). However, while a large body of evidence exists to demonstrate the negative health impacts of wildfires and wildfire smoke [21–23], little evidence exists to understand how a resident's underlying health status may impact their evacuation choices.

The aim of this study is to leverage a 2016 public health surveillance survey, representative of individuals in Tasmania, Australia, which asked specific questions about intentions and plans in response to wildfire for residents that lived in close proximity to bushland [24]. We aimed to explore the association between resident evacuation intentions and sociodemographic characteristics and health outcomes. In early 2016, large areas of the Tasmanian wilderness areas were affected by wildfires that were widely reported in the national and international media [25], with elevated smoke pollution affecting many population centres [26]. As a result of these preceding events, we anticipated most people surveyed in later 2016, particularly those with poorer health, would have heightened awareness of fire and likely plan on leaving their homes in response to a wildfire threat, rather than staying and attempting to defend their properties. The 2016 survey also provided an invaluable baseline to gauge the effectiveness of subsequent education campaigns to promote self-evacuation to avoid catastrophic fire weather [27].

1.1. Study setting

1.1.1. Population and governance

The temperate island state of Tasmania is located to the south of mainland Australia, with an estimated population of 571 500 in 2022 [28]. The population is clustered into three major centres focused on Hobart in the south; Launceston in the north; and a group of coastal towns including Burnie, Wynyard, and Devonport in the north-west. Tasmania has 29 local government areas (LGAs), that can be broadly classified as urban/regional or rural/remote based on population density (see Figs. 1 and 2).

1.1.2. Wildfire risk

Approximately 98 % of Tasmania's land area is classed as fire-prone [29], and wildfire has the highest risk profile of all natural hazards in Tasmania [30]. Highlighting this risk, recent major events have occurred in 2013 (the Dunalley-Forcett, Lake Repulse and Bicheno fires), 2016 (North West fires) and 2019 (Gell River, Riveaux Road and Miena fires) [31]. Tasmania's wildfire risk is projected to increase in a warming climate, with likely increases in air temperature and soil dryness, longer warm seasons, and earlier season occurrences of dry lightning ignitions all contributing to greater frequency and intensity of wildfire events [32–34].

Tasmania presents as an excellent model system in which to investigate wildfire evacuation intentions. Wildfire risk is ubiquitous across both urban/regional and rural/remote populations and different LGAs (see Fig. 3). For example, Hobart, the capital city of Tasmania, includes suburbs with some of the highest risk in the state, while the rural LGA of Latrobe has the lowest wildfire risk.
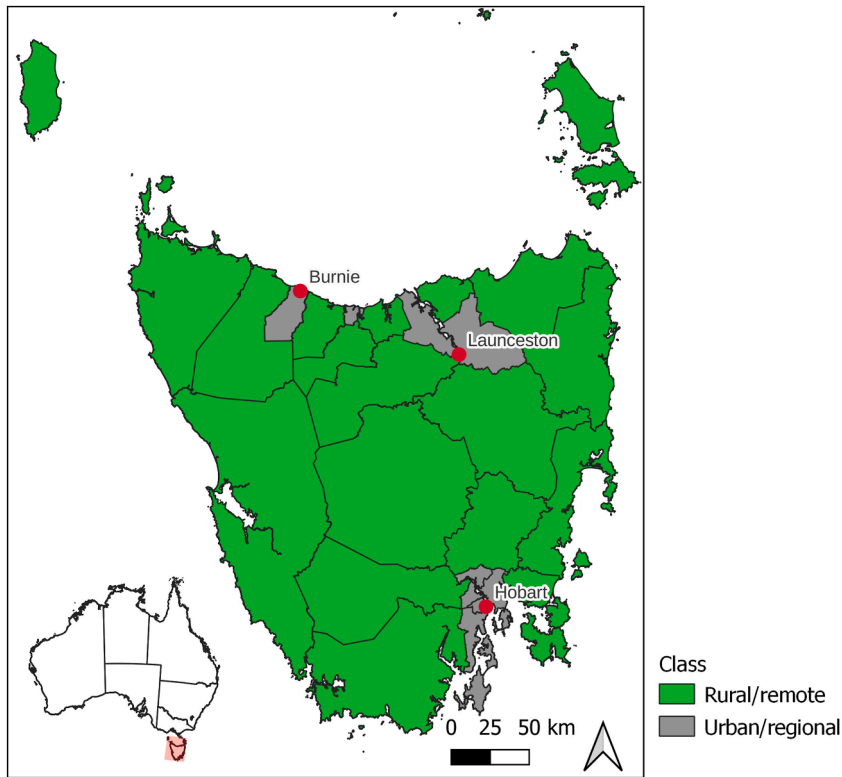
Fig. 1. Tasmania's urban/regional and rural/remote LGA boundaries, showing major population centres.
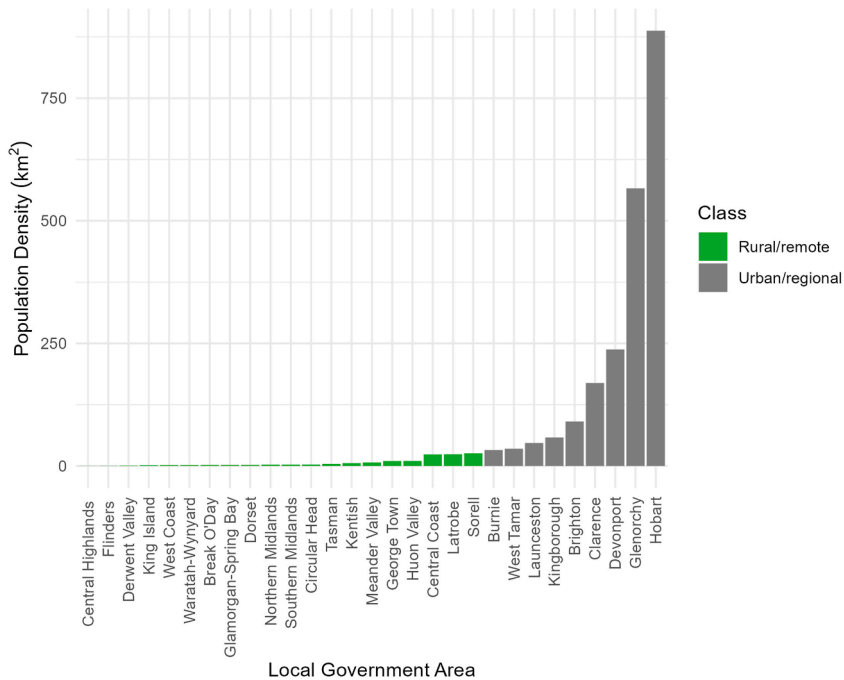
Fig. 2. Tasmanian LGAs by population density, showing urban/regional and rural/remote classifications.

1.1.3. Population health survey

The Tasmanian Department of Health conducts the Tasmanian Population Health Survey (TPHS) every three years, an anonymous, representative, population-based survey. The survey collects data on various sociodemographic variables and health risks, behaviours, and outcomes (see Section 2: Methods). For the first time in 2016, data were also collected on wildfire evacuation inten-

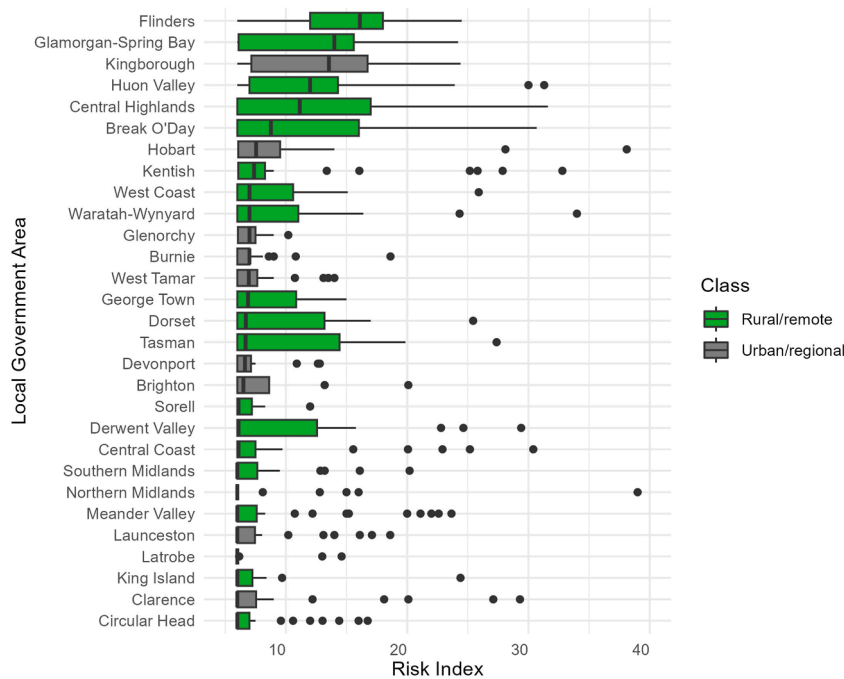**Fig. 3.** Wildfire risk index variation in Tasmanian LGAs. Risk index was calculated at the suburb level within each LGA, using the 90th percentile of the property-level risk index measure. The wildfire risk index used here was calculated using the approach outlined in Supplementary Material (Section 1: Calculation of wildfire risk index).

tions, in response to the increasing risk of climate change, and the need to gather data on population preparedness for climate-related hazards such as heatwaves and wildfires.

2. Methods

2.1. Tasmanian Population Health Survey data

The TPHS collected data from a representative sample of 6300 non-institutionalised Tasmanian residents aged 18 years and over, recruited via random digit dialling of landline (4500 responses) and mobile phones (1800 responses). A computer-assisted telephone interview was used to gather information on sociodemographic factors (e.g., age, sex, location, education, and income), health behaviours and risk factors (e.g., physical activity, diet, smoking, and alcohol intake), and physical and mental health status (e.g., presence of doctor-diagnosed medical conditions and self-reported psychological distress). Interviews were conducted in October and November 2016, with a response rate of 64.4 %. Population weighting was applied to calculate and report estimates but not used in this analysis.

In 2016, for the first time, survey participants were also asked if their home was in an area at risk from wildfires, defined as living within 100 m of bush larger than 100 m by 100 m in area. This definition of risk is used by the Tasmania Fire Service [29] and is similar to other jurisdictions [35,36], based on research demonstrating 85 % of fatalities occur within 100m of bushland edge [37]. Respondents who answered 'Yes' to this question were then asked about their evacuation intentions in response to a nearby wildfire, choosing responses from the following list of options.

a) I would leave immediately without any further prompting
b) I would leave immediately if I thought the Fire Danger Rating was too high
c) I would wait and leave after official warnings were issued (Tasmania Fire Service website, ABC radio, SMS message etc.)
d) I would wait and leave after others confirmed there was a threat or I saw cars leaving the area
e) I would stay as long as I could and only leave if I believed there was an immediate threat to my life or safety
f) I would not leave
g) Don't know/prefer not to say

For analysis purposes, options (a)-(c) were categorised as 'leave' (as a response to official advice), and options (d)-(f) were categorised as 'stay'.

Two new variables were calculated to describe (i) the presence of any chronic medical conditions and (ii) the number of chronic medical conditions captured in the TPHS other than asthma, including a medical diagnosis of heart disease, stroke, diabetes, arthritis, osteoporosis or cancer. All variables from the TPHS used for this study are listed in Table 1.

Table 1

Sociodemographic and health outcomes in the 2016 TPHS used for this study.

Variable	Source	Variable type
Sex	TPHS	Binary (male/female)
Age	TPHS	Binary (under 65/65 and over)
Location	Calculated[a]	Binary (urban/regional and rural/remote)
Educational attainment[b]	TPHS	Continuous (1–5)
Employment status	TPHS	Categorical (employed/retired/not in labour force)
Financial security	TPHS	Binary (yes/no)
Children in house	TPHS	Binary (yes/no)
Self-assessed health status	TPHS	Categorial (poor/fair/good/very good/excellent)
Presence of any chronic medical condition (excluding asthma)	TPHS	Binary (yes/no)
Sum of all chronic medication conditions (excluding asthma)	TPHS	Continuous (1–6)
Asthma diagnosed	TPHS	Binary (yes/no)
Depression/anxiety diagnosed	TPHS	Binary (yes/no)
Evacuation intention	TPHS	Binary (leave/stay)
Home fire risk	TPHS	Binary (yes/no)

[a] see Section 1.1.1.

[b] Educational attainment variables: 1 = Never attended school/attended primary school; 2 = High school; 3 = Secondary college; 4 = Trade certificate or diploma; 5 = Undergraduate/postgraduate degree.

2.2. Data analysis

The proportion of respondents in each TPHS variable category used in analysis were described (see Table 2). To assess initial associations, we conducted a correlation calculation between all ordinal survey variables, including leave intention, using the *corrgram* package in R [38]. Pairwise Pearson correlation coefficients were plotted, and the correlations were interrogated to select a suitable set of variables for ordination and modelling in order to avoid strongly colinear variables.

To evaluate patterns of clustering among our data variables, we conducted a principal components analysis (PCA) on a subset of variables collected in the TPHS (age category, asthma diagnosis, asthma plan, diabetes, high sugar, self-assessed health status, heart condition, stroke, cancer, osteoporosis, depression/anxiety, arthritis, mental health help, financial security, intention to leave, children present in house, Aboriginal/Torres Strait Islander, birthplace, educational attainment, employment status, student status, retired status, unemployed status, home duties status, sex, income and urban/rural location). Ordination was performed using the *ordr* package [39], and scaling and centring were enabled for the ordination points. This enabled identification of variables most suitable to include in the regression models.

Finally, we used log binomial regression to calculate the association between the outcome of evacuation intention (leave or stay), and the sociodemographic variables (sex, age, location, education, employment, financial security and children in house) and health outcome variables (self-assessed health status, presence of a chronic health condition, cumulative chronic health conditions, doctor-diagnosed asthma and doctor-diagnosed depression or anxiety). Participants responding with 'Don't know' or 'Prefer not to say' options were omitted from the model. Risk ratios (RR) and 95 % confidence intervals (CI) were estimated. The following model was used:

> model = Leave Intention ~ Location + Age + Children In House + Financially Secure + Educational Attainment + Employment (Not In Labor Force) + Employment (Retired) + Chronic Health Condition + Number of Chronic Health Conditions + Depression/Anxiety + Asthma + Self-assessed Health Status + Sex

Results were further analysed separately by sex (male/female), where the model used for this analysis was:

> model = Leave Intention ~ Location + Age + Children In House + Financially Secure + Educational Attainment + Employment (Not In Labor Force) + Employment (Retired) + Chronic Health Condition + Number of Chronic Health Conditions + Depression/Anxiety + Asthma + Self-assessed Health Status

All analysis was performed in R v4.3.0 [40].

3. Results

3.1. Wildfire risk index and self-reported risk

The proportion of residents in each LGA reporting their home was at risk from wildfires (i.e. within 100 m of bush larger than 100 m by 100 m in area) was compared to the median wildfire risk for that LGA. There was no clear pattern of risk correlation, highlighting the widespread fire risk among LGAs with strongly contrasting social and biophysical environments (see Fig. 4).

3.2. Tasmanian Population Health Survey data

The 2016 TPHS had a total of 6300 respondents, with 2100 respondents from each of the three major regions of South, North and Northwest Tasmania. All LGAs were represented with the exception of Central Highlands, which is the least populated of all the Tas-

Table 2

Social, demographic and health characteristics of 2016 TPHS participants (by total participants, male and female).

Characteristic[a]	n (%age)		
	Total participants	Male	Female
Age			
18–24 years	144 (2.3 %)	68 (2.6 %)	76 (2.1 %)
25–34 years	311 (4.9 %)	132 (5.0 %)	179 (4.9 %)
35–44 years	549 (8.7 %)	194 (7.4 %)	355 (9.7 %)
45–54 years	1001 (15.9 %)	428 (16.3 %)	573 (15.6 %)
55–64 years	1485 (23.6 %)	650 (24.8 %)	835 (22.7 %)
65+ years	2810 (41.7 %)	1154 (43.9 %)	1656 (45.1 %)
Sex[b]			
Male	2626 (41.7 %)	2626 (100 %)	–
Female	3674 (58.3 %)	–	3674 (100 %)
Household income			
Less than $50,000	3130 (49.7 %)	1170 (44.6 %)	1960 (53.3 %)
Between $50,000 and $100,000	1543 (24.5 %)	692 (26.4 %)	851 (23.2 %)
Over $100,000	1028 (16.3 %)	561 (21.4 %)	467 (12.7 %)
Highest educational attainment			
Never attended/primary school	111 (1.8 %)	46 (1.8 %)	65 (1.8 %)
High school	1816 (28.8 %)	691 (26.3 %)	1125 (30.6 %)
Secondary college	826 (13.1 %)	319 (12.1 %)	507 (13.8 %)
Trade certificate or diploma	1857 (29.5 %)	865 (32.9 %)	992 (27.0 %)
Undergraduate/postgraduate degree	1583 (25.1 %)	663 (25.2 %)	920 (25.0 %)
Other	41 (0.7 %)	10 (0.4 %)	31 (0.8 %)
Employment status			
Employed	2623 (41.6 %)	1193 (45.4 %)	1430 (38.9 %)
Not in the labour force	760 (12.1 %)	241 (9.2 %)	519 (14.1 %)
Student	85 (1.3 %)	32 (1.2 %)	53 (1.4 %)
Retired	2806 (44.5 %)	1146 (43.6 %)	1660 (45.2 %)
Other	2 (0.0 %)	1 (0.0 %)	1 (0.0 %)
Children in the household			
Yes	1240 (19.7 %)	476 (18.1 %)	764 (20.8 %)
No	5043 (80.0 %)	2143 (81.6 %)	2900 (78.9 %)
Have financial security			
Yes	5149 (81.7 %)	2247 (85.6 %)	2902 (79.0 %)
No	986 (15.7 %)	314 (12.0 %)	672 (18.3 %)
Self-assessed health status			
Excellent	617 (9.8 %)	259 (9.9 %)	358 (9.7 %)
Very good	1637 (26.0 %)	677 (25.8 %)	960 (26.1 %)
Good	2369 (37.6 %)	967 (36.8 %)	1402 (38.2 %)
Fair	1257 (20.0 %)	545 (20.8 %)	712 (19.4 %)
Poor	401 (6.4 %)	169 (6.4 %)	232 (6.3 %)
Asthma diagnosed			
Yes	1367 (21.7 %)	484 (18.4 %)	883 (24.0 %)
No	4915 (78.0 %)	2134 (81.3 %)	2781 (75.7 %)
Asthma plan			
Yes	591 (9.4 %)	69 (2.6 %)	423 (11.5 %)
No	203 (3.2 %)	168 (6.4 %)	134 (3.6 %)
Diabetes diagnosed			
Yes	777 (12.3 %)	372 (14.2 %)	405 (11.0 %)
No	5514 (87.5 %)	2249 (85.6 %)	3265 (88.9 %)
Heart disease diagnosed			
Yes	810 (12.9 %)	438 (16.7 %)	372 (10.1 %)
No	5466 (86.8 %)	2177 (82.9 %)	3289 (89.5 %)
Stroke diagnosed			
Yes	349 (5.5 %)	159 (6.1 %)	190 (5.2 %)
No	5940 (94.3 %)	2463 (93.8 %)	3477 (94.6 %)
Cancer diagnosed			
Yes	938 (14.9 %)	397 (15.1 %)	541 (14.7 %)
No	5350 (84.9 %)	2224 (84.7 %)	3126 (85.1 %)
Osteoporosis diagnosed			
Yes	900 (14.3 %)	201 (7.7 %)	699 (19.0 %)
No	5358 (85.0 %)	2406 (91.6 %)	2952 (80.3 %)
Arthritis diagnosed			

Table 2 (*continued*)

Characteristic[a]	n (%age)		
	Total participants	Male	Female
Yes	2711 (43.0 %)	942 (35.9 %)	1769 (48.1 %)
No	3562 (56.5 %)	1676 (63.8 %)	1886 (51.3 %)
Depression or anxiety diagnosed			
Yes	1649 (26.2 %)	512 (19.5 %)	1137 (30.9 %)
No	4633 (73.5 %)	2105 (80.2 %)	2528 (68.8 %)
Mental health help sought			
Yes	798 (12.7 %)	256 (9.7 %)	542 (14.8 %)
No	5488 (87.1 %)	2361 (89.9 %)	3127 (85.1 %)

[a] Missing data not reported.

[b] Non-binary responses were not captured in the 2016 TPHS, therefore we were only able to analyse on binary sex data (male/female).
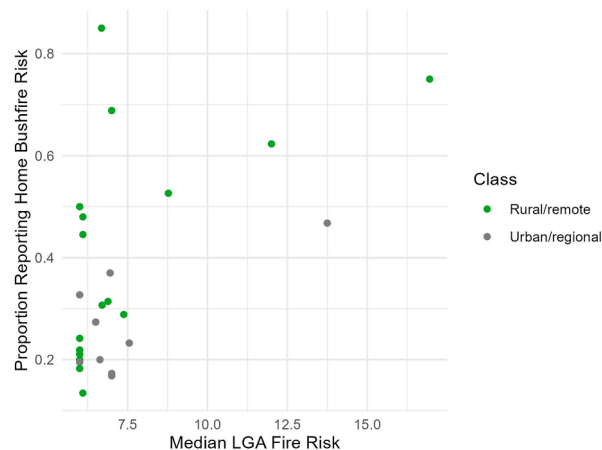

Fig. 4. Scatterplot showing self-reported household fire risk v median suburb wildfire index, for the 29 LGAs in Tasmania, Australia.

manian LGAs. Five hundred and sixteen suburbs were represented from a total of 776 Tasmanian suburbs. Females and older age groups were over-represented when compared to Tasmanian population data [41]. Table 2 shows the social, demographic and health characteristics of the total population, of males and of females.

Over 76 % of respondents (n = 4736) reported at least one of the following medical conditions: asthma, cancer, diabetes, heart disease, stroke, osteoporosis, arthritis or depression/anxiety. Just over 26 % (n = 1666) of respondents reported living in a wildfire risk area, while just over 73 % of respondents reported not being at risk (n = 4607). If a respondent reported being at risk, they were asked to describe their evacuation intentions if a wildfire were burning near their home. Using the 'leave' and 'stay' categories described in Section 2.1, 65.2% (n = 1064 respondents) reported they would leave, while 34.8 % (n = 568) reported they would stay (with 2.1 % of participants choosing 'other' or not responding). Most of the respondents choosing to stay believed they could protect their home, or they had adequate shelter on the property. Four respondents cited animals or livestock as the reason for not leaving.

Correlation table outputs demonstrated a strong correlation between evacuation intention and sex, with weaker correlations for other sociodemographic and health-related variables (see Supplementary Materials, Fig. S1). Based on the correlation table output, associations with sex were explored in greater detail using PCA.

The first two principal components explained 21.7 % variance, clearly identifying intercorrelated demographic, health and financial variables. For example, age and retirement status were strongly associated with each other, and in turn with a range of chronic health conditions (cancer, arthritis, osteoporosis, and heart disease). Retirement and older age were negatively associated with children being present in the home. Employment status was correlated with income and educational attainment, while financial security was correlated with males, fewer chronic health conditions and higher self-assessed health status. Importantly, the vectors for urban/rural status, and for intention to leave were poorly related, indicating little discrimination in the other variables across the urban/rural or intention to leave categories (see Supplementary Materials, Fig. S2).

Fig. 5 shows a comparison of evacuation intentions between males and females, demonstrating females were more likely to leave and males more likely to stay (noting the three responses above the horizontal line were categorised as 'leave' and the three responses below the horizontal line were categorised as 'stay').

Regression analysis demonstrated that selected sociodemographic and health-related factors were associated with choosing to leave. Being female was the strongest predictor (RR = 1.52, 95 % CI [1.40–1.66]), while having higher educational attainment (RR = 1.02, 95 % CI [1.00–1.03]) was also statistically significant. The presence of doctor-diagnosed depression/anxiety (RR = 1.07, 95 % CI [1.00–1.15]) fell marginally outside statistical significance (see Table 3 and Fig. 6a for full results).
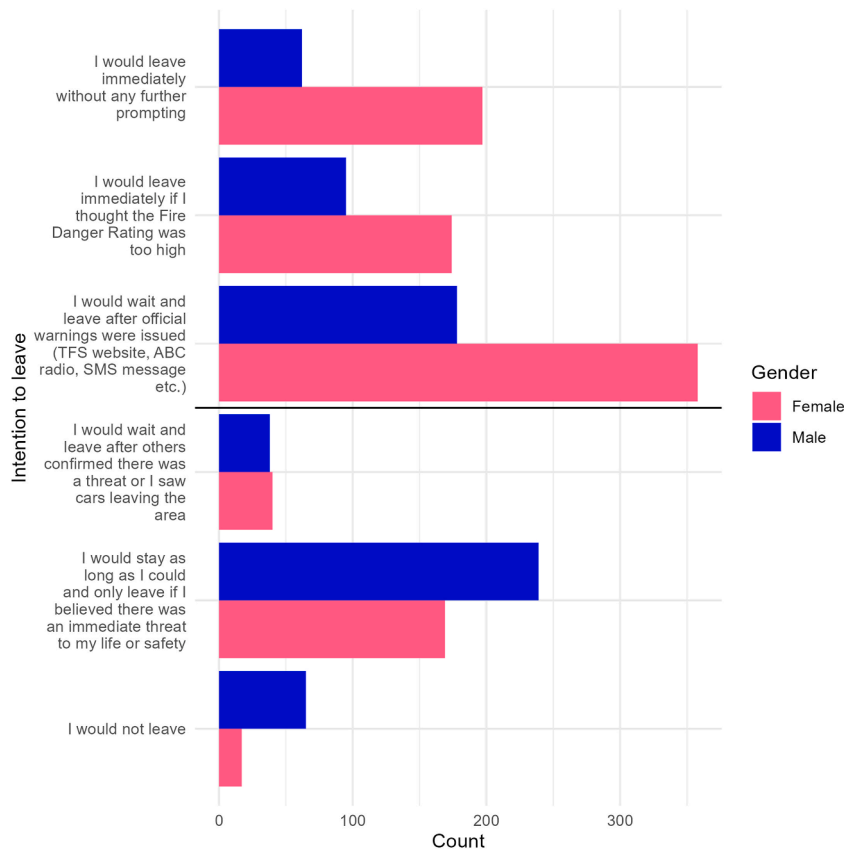
Fig. 5. Sex comparison of wildfire evacuation intentions among a representative sample of 1628 people in Tasmania, Australia (2016).
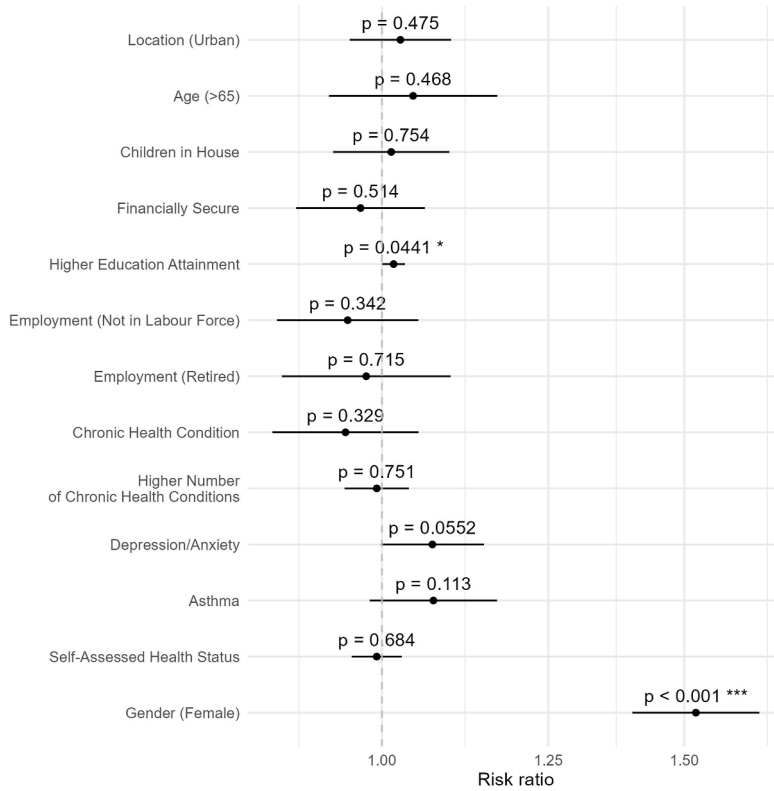
Table 3

Risk ratios, 95 % confidence intervals and significance levels for the association between leave intention and sociodemographic and health outcomes, in a representative sample of 1628 people in Tasmania, Australia (2016).

Predictors	Leave Intention		
	Risk ratio	95 % CI	*p*
Location (Urban)	1.03	0.96–1.11	0.475
Age ($>$65)	1.04	0.93–1.17	0.468
Children in house	1.01	0.94–1.09	0.754
Financially secure	0.97	0.89–1.06	0.514
Higher educational attainment	1.02	1.00–1.03	**0.044***
Employment (Not in labour force)	0.96	0.87–1.05	0.342
Employment (Retired)	0.98	0.87–1.10	0.715
Chronic health condition	0.95	0.86–1.05	0.329
Higher number of chronic health conditions	0.99	0.95–1.04	0.751
Depression/Anxiety	1.07	1.00–1.15	0.055
Asthma	1.07	0.98–1.17	0.113
Self-assessed health status	0.99	0.96–1.03	0.684
Sex (Female)	1.52	1.40–1.66	**$<$0.001***

Bold and * indicates *p* < 0.05.

When analysed by sex, higher educational attainment (RR = 1.05, 95 % CI [1.01–1.09]) and asthma (RR = 1.28, 95 % CI [1.04–1.57]) were significantly associated with an intention to leave for males, while the presence of a chronic condition was significantly associated with an intention to stay (RR = 0.78, 95 % CI [0.62–0.99]) (see Table 4 and Fig. 6b for full results). For females, a less precise association with an intention to leave was found for the presence of doctor-diagnosed depression/anxiety (RR = 1.08, 95 % CI [1.00–1.16]), however, no socioeconomic or health-related factors appeared to be statistically significant (see Table 4 and Fig. 6b for full results).

(a) All Respondents
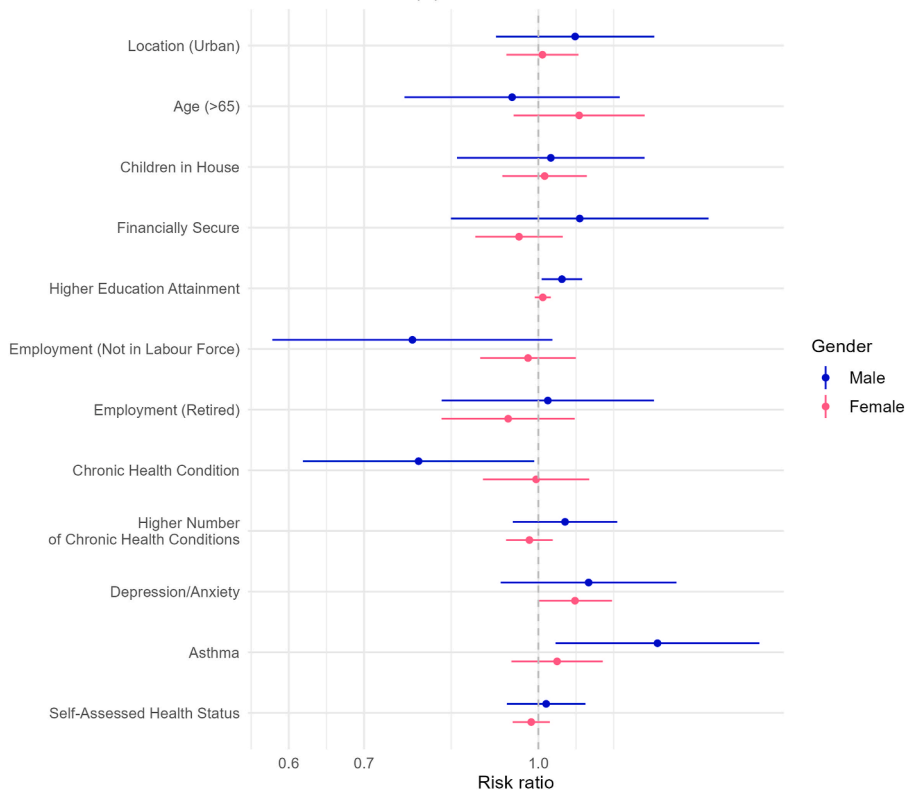

(b) Male vs. Female

Fig. 6. Risk ratios and 95 % confidence intervals for the association between (a) leave intention and sociodemographic and health outcomes for all participants and (b) leave intention and sociodemographic and health outcomes for males and females among a representative sample of 1628 people in Tasmania, Australia (2016).

Table 4

Risk ratios, 95 % confidence intervals and significance levels for the association between leave intention and sociodemographic and health outcomes for males and females, Tasmania, Australia (2016).

Predictors	Leave Intention					
	Male (n = 674)			Female (n = 954)		
	Risk ratio	95 % CI	p	Risk ratio	95 % CI	p
Location (Urban)	1.08	0.92–1.27	0.363	1.01	0.94–1.09	0.825
Age (>65)	0.95	0.76–1.18	0.632	1.09	0.95–1.24	0.223
Children in house	1.03	0.85–1.24	0.795	1.01	0.93–1.10	0.771
Financially secure	1.09	0.84–1.42	0.529	0.96	0.88–1.05	0.385
Higher educational attainment	1.05	1.01–1.09	**0.023***	1.01	0.99–1.03	0.277
Employment (Not In labour force)	0.77	0.58–1.03	0.078	0.98	0.89–1.08	0.671
Employment (Retired)	1.02	0.82–1.27	0.862	0.94	0.82–1.08	0.374
Chronic health condition	0.78	0.62–0.99	**0.042***	1.00	0.89–1.11	0.933
Higher number of chronic health conditions	1.06	0.95–1.18	0.317	0.98	0.94–1.03	0.451
Depression/Anxiety	1.11	0.93–1.33	0.263	1.08	1.00–1.16	0.053
Asthma	1.28	1.04–1.57	**0.022***	1.04	0.95–1.14	0.422
Self-assessed health status	1.02	0.94–1.10	0.698	0.99	0.95–1.02	0.452

Bold and * indicates $p < 0.05$.

4. Discussion

We found that in Tasmania, Australia, social and health outcomes including being female and having a higher educational attainment, were associated with a higher likelihood of intending to 'leave' in response to a nearby wildfire. When analysed separately by sex, having higher educational attainment and having asthma were clearly associated with intention to leave for males but not females. Conversely, the presence of a chronic condition for males was associated with an intention to 'stay'. For females, while there were no statistically significant associations, imprecise positive associations were observed for depression/anxiety and intention to leave.

4.1. Sex influences on intention to leave

Our findings with regard to sex in wildfire evacuation intentions align strongly with several other studies showing females are more likely than males to leave during a wildfire threat, as opposed to stay and defend [17–19]. This is further expanded upon in literature related to wildfire mortality and wildfire risk, where sex/gender is consistently and strongly indicated as a factor. For example, Haynes et al. [42] show that fatalities during wildfires were significantly more likely to occur in males, and that males were more likely to die as a result of defending property, whereas females were more likely to die sheltering from fires. Whittaker et al. [43] discuss gender-based risk differences during a wildfire as a result of work type, domestic and political distributions of power, care needs and expectations, social role expectations and economy. Furthermore, in their analysis of data collected from rural landholders in south-east Australia, Eriksen et al. describe how "key gender differences exist within landholders' bushfire risk awareness, bushfire knowledge, the perceived need for bushfire preparedness measures, the willingness to perform certain tasks, and the belief in personal capacity to act" [17]. Wildfire management strategies differ between genders, as a reflection of gendered societal norms most often depicting males as key protectors of homes and properties, while females are more likely to act primarily in supporting or caring roles [44].

4.2. Health conditions

To the best of our knowledge, ours is the first study to evaluate associations between health status and intention to leave during periods of higher risk from wildfires. The health condition most strongly associated with an intention to leave was asthma. Interestingly, while having an asthma diagnosis and an asthma plan were both more commonly reported by females, we found that asthma was only associated with an intention to leave in males. Our data cannot explain the reason for the differences we observed. However, as females were much more likely to report an intention to leave without additional prompts, it is possible health status was less likely to be a factor in decision making for females than for males. Previous studies have found gender differences in perceptions of people living with asthma, with men reporting better quality of life, fewer symptoms, less concern with and less impact of asthma than women [45,46]. However, it is unclear how this might influence decisions made during wildfire risk episodes.

A statistically significant association with the presence of a chronic health condition other than asthma was in the opposite direction to asthma for males (Fig. 6) and was not associated with evacuation intentions for females. The reasons for this are speculative. It is possible the more immediate and obvious impact of asthma symptoms as a response to heat and smoke related to wildfires are more influential than the far less frequent and less apparent symptoms associated with changes to underlying cardiovascular risk during exposure to natural disasters and air pollution episodes [47,48].

When compared to males, females in the study group more frequently reported a diagnosis of depression or anxiety, and more frequently sought mental health support than males (Table 2). These results are generally consistent with previous studies examining differences in mental health outcomes related to gender [49,50]. While not statistically significant, the presence of doctor-diagnosed anxiety or depression was associated with a higher likelihood of intending to leave in females than in males (Fig. 6), the opposite pattern to the sex/gender differences observed with doctor-diagnosed asthma. This has not been well explored in previous studies. Most studies on mental health and natural disasters concentrate on post-event mental health outcomes rather than preparedness and planning. An exception is Every et al. [51], who found low depression scores and low stress scores were associated with greater measures of preparedness, indicating that better mental health is associated with increased preparedness. Other studies have found that lower levels of preparedness were associated with an increased likelihood of intending to leave [20]. This could be one pathway by which mental health might affect intentions to evacuate. Another possibility is that people living with anxiety could be more risk averse and therefore more likely to plan on leaving. Further research is warranted to explore and replicate these findings in relation to chronic health conditions, mental health, preparedness actions and intention to leave across multiple settings.

4.3. Sociodemographic differences

In our study, higher educational attainment was associated with an intention to leave, with the association being strongest in males (Fig. 6). This result was partially consistent with a study by Mozumder et al. [18] in Albuquerque, USA, who found years of schooling was positively associated with a householder's concern that wildfires may endanger their home, but not with the probability of intended voluntary or mandatory evacuation.

Similarly to McLennan et al. [19], we found no associations between intention to leave and location (urban vs rural), noting that McLennan et al. conducted research in the time after a severe wildfire event as opposed to prior to an event, potentially making a comparison of these results less robust. Our finding is contrary to findings from a previous similar survey investigating leave intentions conducted across fire-prone areas of Australia [8], which found respondent's place of residence was associated with evacuation intention. McLennan et al. [19] also found that having children in the home was associated with a decision to leave, while our research did not detect an association, again noting that McLennan et al. is reporting on event outcomes rather than intentions. We were unable to find other studies that reported evaluated evacuation intentions in the context of employment status or self-reported financial security.

4.4. Strengths and limitations

Strengths of our study include the novel ability to link information about evacuation intentions to sociodemographic and health variables in a large, representative, state-wide survey. Limitations include using self-assessment of proximity to bushland and self-reported data for all sociodemographic, health outcome and evacuation intention data used in this study, introducing a higher risk of measurement bias than when using data obtained by objective measurement. We acknowledge that self-reporting can especially lead to a bias towards more socially acceptable responses for sensitive personal information such as income, employment status and mental health outcomes [52]. In the 2016 TPHS, questions relating to evacuation intention were not asked of those who did not believe that they lived in close proximity to bushland, therefore we were unable to test if responses could have been different in people living in areas with lower versus higher wildfire risk. The questions in the survey were hypothetical in nature and we do not know how well a reported intention will correlate with actual behaviour in the event of a risk from wildfire. Finally, a cross-sectional study design, such as ours, is not able to provide information about causal associations.

4.5. Policy implications

Our results provide greater insight and understanding into the drivers of wildfire evacuation intentions in Tasmania, Australia. This information is useful for policy makers and communication specialists across various authorities who have carriage of wildfire-related safety messaging. For example, specific masculine-targeted marketing campaigns emphasising the 'leave early' narrative may be more beneficial than those aimed at a general audience.

Placing our findings in the context of the Royal Commission into National Natural Disaster Arrangements [53], our study provides strong evidence to support Recommendation 10.1: Disaster education for individuals and communities. The Commission Report states that while ' … individuals and communities … have an important role in ensuring that, if a disaster were to strike, they are prepared to manage the consequences … governments have a critically important role in providing information on disaster risks via community education and engagement programs'. Furthermore, the report recommends that these programs 'should be fit for purpose – accounting for changing risk profiles and community demographics' [53]. Our research provides specific, localised information on the risk profile and evacuation intentions of the Tasmanian community, which can be of benefit to local fire authorities in understanding the most beneficial engagement strategies. However, further research is needed to understand and close the gap between understanding and action around wildfire risk.

4.6. Future research

While the 2016 TPHS captures detail relevant to the time, it would be beneficial to repeat questions about evacuation intentions in subsequent TPHS data collections to create a longitudinal dataset. Determining a trend towards 'leave' or 'stay' preferences over time, and how these are influenced by various sociodemographic and health variables, would further assist in targeting appropriate communication messaging regarding the safest option. Specifically, the 2016 data provide a baseline to evaluate the impact of the national fire danger rating system introduced in 2022, that recommends evacuation from wildfire prone areas in response to forecast catastrophic fire weather. This new advice has been accompanied by major educational campaigns [27], so it would be anticipated

that there would have been a substantial change in evacuation intentions in response to catastrophic fire weather since the data were collected for our study in 2016. Further qualitative research examining the underlying reasons behind various evacuation actions and intentions would be useful in formulating and refining targeted policy responses to increase safety. Finally, research examining intended evacuation actions prior to an event, and actual evacuation actions during an event, would be helpful in understanding the knowing-doing gap.

5. Conclusion

We surveyed a representative sample (n = 6300) of Tasmanians, 26 % of whom lived near bushland. We found females were much more likely than males to leave home under the threat of a wildfire, and that among males but not females, higher educational attainment and a diagnosis of asthma were significantly associated with a higher likelihood of intending to leave. Associations with other chronic physical or mental health conditions were less clear. These results have implications for policy makers and communication specialists targeting priority groups in preparing for higher risk periods associated with wildfire events. Further, our study provides important baseline data of wildfire evacuation intentions that precede the current and widely promoted Australian advice of leaving early in response to catastrophic fire weather conditions. An important avenue of further research is to investigate the effectiveness of the campaigns promoting advice to 'leave early', and evaluating the concordance between intentions in a hypothetical scenario, and actual behaviour during high risk periods for wildfire.

Ethics statement

Ethics approval was granted by the Tasmanian Health and Medical Human Research Ethics Committee (ID 28835; March 4, 2023).

Declaration of funding

CRediT authorship contribution statement

Sharon L. Campbell: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Grant J. Williamson:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis. **Fay H. Johnston:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization. **David M.J.S. Bowman:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2024.104712.

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