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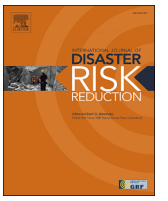

Community education on the health impacts of bushfires: Evaluation of an online pilot short course in Tasmania, Australia

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ABSTRACT

Bushfires and smoke pose substantial risks to physical and mental health across exposed populations. Enhanced community-level knowledge and response capability may promote exposure reduction and therefore protect health, however few interventions exist to achieve this goal. We developed an online short course, 'Bushfires and Your Health', and piloted it with older adults as a vulnerable group. We evaluated course satisfaction, factors associated with course enrolment and completion, the likelihood of increased bushfire knowledge and response capability, and the likelihood of participants undertaking risk-mitigating or health-promoting actions. We (i) used a pre-post-course survey in the intervention group and a control group (who did not undertake the course); (ii) gathered data from the intervention group via a post-course feedback survey; and (iii) analysed participant discussion board submissions for evidence of course-related behaviour change. Compared to the control group, course enrolment was significantly positively associated with several demographic characteristics, including being retired (OR = 1.32, 95 % CI [1.02–1.71]), living in proximity to bushland (OR = 1.58, 95 % CI[1.23–2.04]) and having an existing bushfire survival plan (OR = 1.34, 95 % CI[1.05–1.70]), and significantly inversely associated with being employed (OR = 0.76, 95 % CI[0.59–0.97]) and having poor bushfire knowledge (OR = 0.78, 95 % CI[0.61–0.99]). Compared to the control group, course completion was significantly associated with increased bushfire knowledge, while enrolment and completion were significantly associated with participants undertaking new actions, including downloading and using an air quality app, developing a bushfire survival plan and making household preparations. An online short course has potential to increase knowledge and preparedness actions when managing bushfires and bushfire smoke.

1. Introduction

Bushfires (also known as wildfires) and bushfire smoke are globally recognised as causing considerable health, social, economic and environmental impacts, including increased mortality and morbidity [1–4]. Climate change projections both worldwide and in Australia estimate a substantial increase in bushfire risk in many regions, even under very low greenhouse gas emission scenarios [5].

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Record-breaking and catastrophic bushfires in Australia, North America and South America in the summers of 2019-21 highlight the present and increasing threat of these events [6–8].

The human health impacts of bushfires and bushfire smoke encompass a wide spectrum of physical and mental health conditions. Multiple studies demonstrate an increased likelihood of cardiovascular, respiratory and/or diabetic events linked to poor air quality resulting from exposure to bushfire smoke [9,10], and emerging evidence supports a link between bushfire smoke exposure and neurological impacts [11]. Research into the mental health outcomes of the 2009 Black Saturday bushfires in Victoria, Australia, demonstrate that anxiety and depression are commonly reported following a bushfire and can persist for a number of years after the event [12]. Furthermore, specific population groups such as the very old (who have an increased likelihood of multiple chronic health conditions), the very young (who have developing body systems), and pregnant women are among those demonstrating a higher risk of poor health from bushfire smoke exposure [13,14].

In this context, managing and adapting to increasing health risks from bushfires and bushfire smoke is urgent, especially in fire-prone residential settings where community education may provide a pivotal role. In Australia, recommendations from the Royal Commission into National Natural Disaster Arrangements, undertaken in the wake of the 2019-20 Australian bushfires, outlined the role of community education to promote resilience (Recommendation 10.1) and the importance of nationally consistent air quality information, health advice and interventions, including targeted health advice to vulnerable groups (Recommendation 14.1) [15].

To date however, few interventions have been designed and evaluated with the aim of increasing community-level bushfire knowledge and response capability, particularly with respect to health-related impacts. Educational interventions designed to promote smoke exposure reduction and consequential health protection may offer a potential adaptation solution, with online education a particularly promising means of achieving maximum reach. While the research base is small, there is evidence to support the potential of technology-based interventions to promote bushfire-related protective actions. For example, a recent pilot using a virtual reality bushfire scenario appeared to increase participants' decisive actions related to bushfires, and led to almost one-third of respondents developing a bushfire survival plan [16]. In a health context, users of a smartphone app communicating air quality and health-related information reported using the app to support exposure reduction decisions [17]. This provides strong rationale to support online education as a potential adaptation pathway, however rigorous evaluation is crucial to ensure effective program design.

1.1. An online short course intervention

In this context, we developed an online short course called 'Bushfires and Your Health,' in response to both an identified need for greater community understanding of air quality measures and the impact of bushfire smoke exposure to health [17,18], and related recommendations from the Royal Commission into National Natural Disaster Arrangements. The course consisted of six modules, covering the impacts of bushfires and bushfire smoke on physical and mental health, how to understand air quality information, and strategies to manage or reduce exposure and related health symptoms. The course engaged participants with a wide variety of design strategies, including written material, illustrations, recorded lectures, interactive quizzes and activities, key point summaries, discussion boards and additional optional readings or videos. A 'notes' function was integrated frequently throughout the modules to encourage active reflection by course participants and match new knowledge with the participant's own circumstances. Emphasis was placed on accessibility, with editing throughout for plain language and the use of a glossary.

In September 2021, the course was piloted to a cohort of adults over 50 years of age in Tasmania, Australia. In this paper, we present an evaluation of the online course.

1.2. Research aims

This study has three research aims: (1) to describe who took the course and how it was experienced by participants, including characteristics associated with course enrolment and completion; (2) to understand if participating in the course changed self-perceived capability to respond to the health risks associated with bushfires, and/or changed bushfire-related knowledge; and (3) to examine what health promotion or risk reduction actions had been undertaken since participating in the course.

1.3. Study setting

Tasmania is an island state in southern Australia, with an estimated population of 571 500 in 2022 [19]. The majority of the population reside in the three major centres of Hobart, Launceston and the north-west town cluster of Burnie, Wynyard, Devonport and Ulverstone [20]. All regions of Tasmania are classified by the Australian Bureau of Statistics as regional or remote [21] (see Fig. 2b).

Bushfire currently has the highest risk profile of all natural hazards in Tasmania [22], with recent major events occurring in 2013, 2016 and 2019. Ninety-eight percent of the Tasmanian population live in a bushfire-prone region [23]. Consistent with research conducted in other regions of the world, bushfire smoke related to these events caused substantial health impacts in Tasmania [24,25]. Tasmania's bushfire risk is projected to increase, with likely increases in air temperature and soil dryness, longer warm seasons and earlier season occurrences of dry lightning ignitions contributing to greater frequency and intensity of events [26–28].

In addition, Tasmania has a higher proportion of population groups at increased risk from poor air quality, including the elderly and those living with chronic conditions such as hypertension, heart disease, asthma and chronic obstructive pulmonary disease, when compared to the overall Australian prevalence of these conditions [29]. These factors potentially increase the likelihood of Tasmanians experiencing poor health outcomes linked to poor air quality exposure.

1.4. Ethics and funding statement

The study was approved by the University of Tasmania Human Research Ethics Committee (25017). Course development was funded by the Natural Disaster Risk Reduction Grant Program.

2. Methods

2.1. Recruitment

Participants were recruited through the ISLAND Resilience Initiative, a longitudinal prospective study investigating how cognition in later life is impacted by traumatic experiences, psychological and biological stress, and various coping and resilience factors. The ISLAND Resilience Initiative is a sub-study of a larger project known as the ISLAND Project, representing a cohort of community-dwelling Tasmanians over 50 years of age [30]. ISLAND Resilience Initiative participants were invited to enrol in the online short course through a range of methods including newsletters and email.

2.2. Study design

We evaluated the course using a mixed methods approach. Mixed methods research serves to connect and integrate different types of datasets [31]. We chose this approach to develop multiple perspectives on the research questions and gain a more complete understanding of our research questions.

The evaluation design was based on the Kirkpatrick Model [32], which emphasises the evaluation of learning programs across multiple outcome levels: (1) student reactions to the course (for example, engagement, enjoyment, perceived relevance); (2) the degree of learning or knowledge gain; (3) whether students go on to apply their learning to their behaviours; and the (4) results or outcomes of those changes. Various critiques of the Kirkpatrick Model identify the difficulties and limitations of evaluating Level 4 [33,34]. In this context, our design sought to evaluate (1) participant reactions to the course, (2) knowledge gain and capability change, and (3) bushfire health-related behaviour change, matching our three research aims (see Section 1.2).

We assessed these outcomes primarily using a pre-post-course survey instrument, leveraging the ISLAND Resilience Initiative cohort who chose not to enrol in the course as a control group. Our design utilised four data sources: (1) pre-collected participant data from the ISLAND Project cohort and (2) pre- and post-course survey data from the ISLAND Project and ISLAND Resilience Initiative, which informed research aims 1, 2 and 3; (3) a post-course feedback survey which informed research aim 1; and (4) data from the course discussion board, which provided supplementary information for research aims 1, 2 and 3. Fig. 1 shows the relationship be-

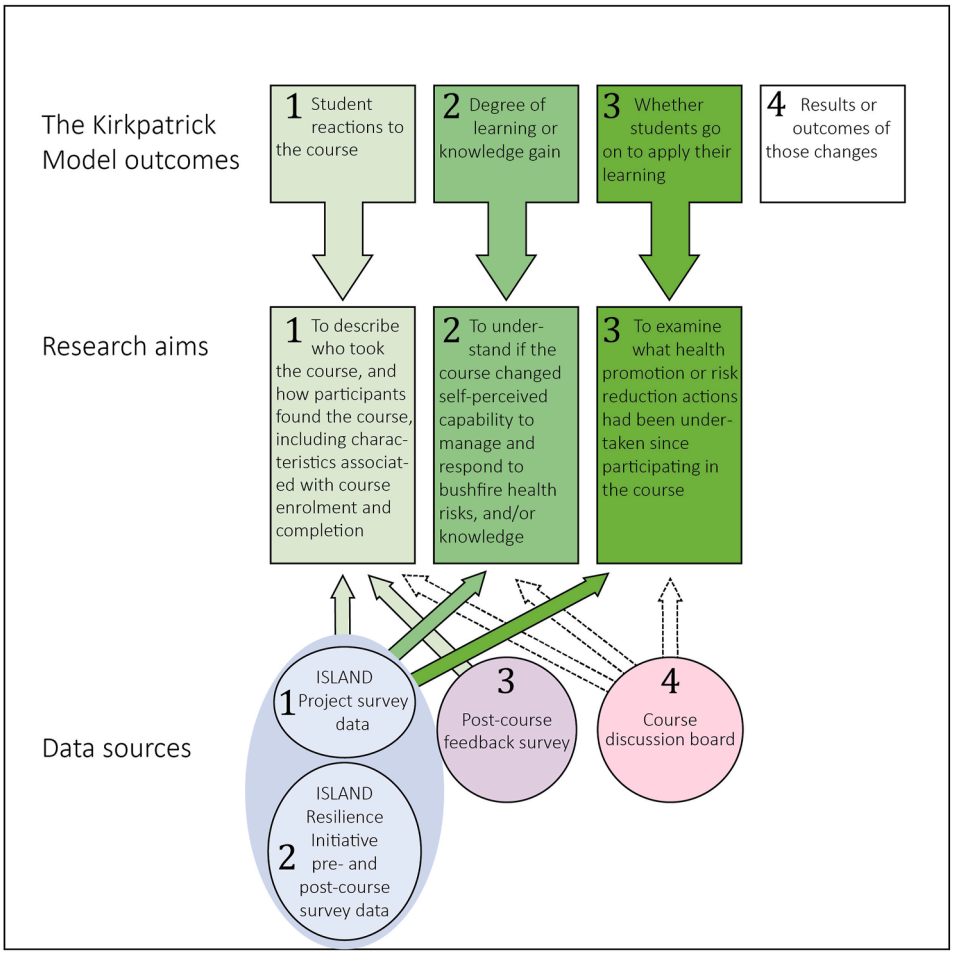

Fig. 1. Relationship between the Kirkpatrick Model outcomes [32], research aims and data sources.

tween the Kirkpatrick Model outcomes, our research aims and data sources, while further details about each component are provided below.

Prior to survey administration, participant information was provided and consent sought via an online portal.

2.3. Data sources

2.3.1. The ISLAND project

All ISLAND Resilience Initiative study participants had previously provided demographic data as part of their recruitment to the ISLAND Project. These data included sociodemographic variables such as residential location, age, gender, marital status, education level, employment and retirement status. Index of Relative Socio-economic Advantage and Disadvantage (IRSAD) quintile data (a spatially aggregated measure of both economic and social circumstances, where scores range from one to five and a lower score indicates higher disadvantage [35]) and regionality area classification (as defined by the Australian Bureau of Statistics [21]) were extracted from residential location information at postcode level. Data regarding a history of previous stroke or transient ischemic attack (TIA) and a previous diagnosis of heart disease were also provided via the ISLAND Project.

2.3.2. Pre- and post-course surveys

In July 2021, pre-course surveys were used to collect additional demographic and health data relevant for the ISLAND Resilience Initiative study, including proximity to bushland, ownership of livestock, carer status, relevant work experience and the presence of asthma, other lung conditions or diabetes. Baseline data on bushfire knowledge and perceived capability to respond in a bushfire were also gathered (see *S1: Supplementary data Part A* for ISLAND Resilience Initiative pre-survey questions). These surveys were applied to the entire ISLAND Resilience Initiative cohort, and data from the surveys were linked to previously collected ISLAND Project data (see Section 2.3.1) through participant ID.

The surveys on bushfire knowledge and response capability were repeated for the whole ISLAND Resilience Initiative cohort shortly after course completion (October 2021). These two surveys were conducted to assess changes in bushfire knowledge and response capability in course participants (both those who completed the course and those who enrolled but did not complete the course) and the control group (who did not enrol in the course).

2.3.3. Post-course behaviour survey

In April 2022, an additional post-course survey was administered to all ISLAND Resilience Initiative participants (both course participants and non-participants) to assess bushfire-related protective behaviours (see *S1: Supplementary data Part B* for ISLAND Resilience Initiative post-survey questions).

2.3.4. Post-course feedback survey

In September 2021, a post-course feedback survey was administered only to course participants, measuring course satisfaction, levels of participant understanding of the course and participant engagement. The survey also requested course feedback from participants (see *S1 Supplementary data, Part C* for post-course feedback survey questions).

2.3.5. Course discussion board

As a feature of the online course, an open discussion board was available for each of the six course modules. The discussion boards invited participants to share key learnings or responses to the module materials, including their reflections on how they might apply their new knowledge to their own circumstances. Participants were actively encouraged to participate in the board, and activity could be submitted anonymously. Discussions were monitored daily, and posts responded to by course administrators.

Data from all sources were de-identified prior to analysis.

2.4. Quantitative methods

Three groups of study participants were identified. Participants were defined as ‘enrolled’ if they had undertaken the course registration procedure, and ‘completed’ if they had accomplished ≥90 % of course material. The group of ISLAND Resilience Initiative participants who did not enrol in the course comprised the control group.

Across all three groups, answers to the pre- and post-course knowledge and response capability surveys were scored and summed to provide one pre-score and one post-score for both perceived response capability and bushfire knowledge. The difference between the pre- and post-scores was then calculated for both perceived capability and bushfire knowledge. The difference scores for bushfire knowledge and perceived capability were then assessed across two comparison groups as: 1) control v enrolled and 2) control v completed.

Responses to the post-course bushfire behaviour survey were analysed across the two comparison groups in the same way.

Post-course feedback survey data were descriptively analysed by calculating counts and proportions of responses to determine participant understanding of and satisfaction with the course.

All data analysis was conducted in R v4.2.2 [36]. Packages used included *tidyverse*, *sf*, *tmap*, *dplyr, ggplot2* and *broom*. Regression analysis was performed using glm() and lm(), where logistic regression was used for binary outcomes, and linear regression was used for continuous outcomes. Odds ratios (OR) and 95 % confidence intervals (CIs) were estimated from logistic regressions, and β-coefficients and 95 % CIs from linear regressions. Age was divided by five to obtain a five-year increment.

2.5. Qualitative methods

Discussion board submissions were analysed for evidence of course-related behaviour change or action. A general inductive approach using the Thomas data analysis framework [37] and NVivo 12 software [38] was used to analyse data. Meanings of the data were identified and systematically sorted into themes and sub-themes [37]. A conceptual model was developed describing the most important themes emerging from the data [39].

3. Results

Our results describe (i) the demographic characteristics of the overall ISLAND Resilience Initiative cohort, those who enrolled in the course and those who completed the course, characteristics associated with course enrolment and completion, and how participants found the course (research aim 1); (ii) if the course created a change in self-perceived capability to manage and respond to the health risks associated with bushfires, and/or changed bushfire-related knowledge when compared to the control group (research aim 2); and (iii) what relevant health promotion or risk reduction actions had been undertaken since participating in the course (research aim 3). Discussion board analysis is also presented to highlight further insights related to all three research aims.

3.1. Demographic characteristics

Table 1 shows a comparison of the ISLAND Resilience Initiative study cohort (n = 1311), enrolled participants (n = 400) and completed participants (n = 162) across a variety of demographic characteristics.

Course participants were located across Tasmania, with a concentration of participants in regions with the greatest population density. Fig. 2a shows the density of participants by postcode with major population centres marked. Fig. 2b shows the regionality classifications with major population centres marked.

3.2. Participant characteristics associated with course enrolment and completion

Approximately 40 % of those enrolled in the course continued to course completion. On average, participants completed approximately 52 % of the course material. Approximately 25 % of those enrolled completed less than 10 % of the course (see Fig. 3).

Various participant characteristics were examined for their association with (i) course enrolment and (ii) course completion. When compared to the control group, course enrolment was significantly positively associated with being retired (OR = 1.32, 95 % CI[1.02–1.71]), living in proximity to bushland (OR = 1.58, 95 % CI[1.23–2.04]) and having an existing bushfire survival plan (OR = 1.34, 95 % CI[1.05–1.70]). Being employed was significantly inversely associated with course enrolment (OR = 0.76, 95 % CI[0.59–0.97]), as was having poor initial bushfire knowledge (OR = 0.78, 95 % CI[0.61–0.99]). Age was also significantly associated with course enrolment, the odds of enrolling in the course increasing by 9 % for every 5 years of age (OR = 1.09, 95 % CI [1.01–1.18]). An elevation in course enrolment, although not reaching statistical significance, was additionally observed for participants owning livestock (OR = 1.28, 95 % CI[0.97–1.69]) (see Fig. 4 and *S2: Supplementary data Part A* for full results).

When compared to the control group, course completion was significantly inversely associated with having poor initial bushfire knowledge (OR = 0.67, 95 % CI[0.48–0.94]), while a positive association, although not statistically significant, was observed with proximity to bushland (OR = 1.34, 95 % CI[0.95–1.93) (see Fig. 4 and *S2: Supplementary data Part A* for full results). Two participants identified as neither male nor female and were not included in the gender analysis due to low numbers.

3.3. Participant understanding and satisfaction

A total of 136 course participants completed the post-course feedback survey. Participants reported they had a clear understanding of what they were going to learn and had a high level of satisfaction with the course. When asked to respond to the statement "I had a clear understanding of what I was going to learn by the end of this course", 93 % (n = 126) replied they agreed or strongly agreed. When asked to respond to the statement "Overall I was satisfied with the course", 94 % (n = 128) replied they agreed or strongly agreed. When asked to respond to the statement "The knowledge I gained from this course will help me to protect my physical and mental health in a bushfire", 94 % (n = 128) replied they agreed or strongly agreed. When asked to respond to the statement "The course helped me feel confident I could protect my physical and mental health in a bushfire", 89 % (n = 121) replied they agreed or strongly agreed. Ninety-nine percent (n = 134) of participants were able to access course materials adequately, and 98 % (n = 133) enjoyed completing the course at their own time and pace.

3.4. Changes to self-perceived capability to respond to bushfires and bushfire-related knowledge

Bushfire knowledge had a possible score range of 0–18. Bushfire knowledge change scores ranged from −5 to +6 for both those who had enrolled (mean = +0.14) and those who had completed (mean = +0.36). When compared to the control group, enrolling in the course showed a non-significant elevation in bushfire knowledge by a score of +0.34 (β = 0.34, 95 % CI[-0.03-0.72]). Completing the course was significantly associated with a change in bushfire knowledge by a score of +0.55 (β = 0.55, 95 % CI[0.13–0.97]).

Capability to respond had a possible score range of 1–5. Capability to respond change scores ranged from −2.00 to +2.25 for those who had enrolled (mean = −0.07), and −1.75 to +2.25 (mean = 0.00) for those who had completed the course. When compared to the control group, an increased change of +0.08 was observed in perceived capability to respond for those who completed, although this was not statistically significant (β = 0.08, 95 % CI[-0.04-0.19]). No difference was found for those who had enrolled (β = −0.02, 95 % CI[-0.11-0.07]) (see Fig. 5a and *S2: Supplementary data Part B* for full results).

Table 1
Comparison of the ISLAND Resilience Initiative study participants, enrolled course participants and participants completing the course, across various demographic characteristics.

Characteristic	ISLAND Resilience Initiative participants (n = 1311)	Enrolled participants (n = 400)	Completed participants (n = 162)
Age			
Mean	64.1	64.8	64.7
SD[a]	7.6	7.4	7.3
range	50–89	50–87	50–86
Gender split (%)			
Male	27.1	26.0	22.8
Female	72.8	73.8	77.2
Other	0.08	0	0
Pref not to say	0.08	0.25	0
IRSAD quintile			
Mean	2.8	2.9	2.8
SD[a]	1.4	1.5	1.4
Retired (%)			
Yes	61.9	67.5	68.5
No	33.4	30.0	30.9
Not available	4.7	2.5	0.6
Employed (%)			
Yes	37.5	33.3	32.1
No	61.3	66.0	67.9
Not available	1.2	0.7	0
Presence of a medical condition[b] (%)			
Yes	39.7	40.7	44.4
No	60.3	59.3	55.6
Carer responsibility (%)			
Yes	10.5	11.0	13.0
No	89.5	89.0	87.0
Relevant work experience[c] (%)			
Yes	37.2	34.5	34.0
No	62.8	65.5	66.0
Have a bushfire survival plan (%)			
Yes	40.6	54.5	57.4
No	59.4	45.5	42.6
Self-rated fire knowledge[d] (%)			
Poor	37.4	41.5	45.7
Good	62.6	58.5	54.3
Proximity to bushland[e] (%)			
Yes	63.3	70.5	69.1
No	36.7	29.5	30.9
Own livestock (%)			
Yes	22.2	25.3	23.5
No	77.8	74.7	76.5
Regionality area[f] (%)			
Inner regional	72.2	71.8	67.9
Outer regional	26.9	27.5	30.9
Not available	0.8	0.7	1.2

[a] Standard deviation.
[b] Medical conditions include self-reported asthma, other lung conditions, diabetes, previous stroke/TIA or diagnosed heart disease.
[c] Relevant work experience includes previous or current experience in health, fire services, emergency services or emergency rescue.
[d] Fire knowledge was calculated as 'Poor' or 'Good', based on a self-reported scale of Very poor/Poor/Neither poor nor good/Good/Very good, where 'Very Poor', 'Poor' and 'Neither poor nor good' were assigned to 'Poor' and 'Good' and 'Very good' were assigned to 'Good' to create a binary variable.
[e] Proximity to bushland is a self-perceived risk, assessed as "If you would feel at risk of harm, or property damage, if a bushfire occurred there" (See *S1: Supplementary data, Part A*).
[f] See Fig. 2b.

3.5. Relevant post-course actions

When compared to the control group, course completion and course enrolment were significantly associated with a number of new health-promoting actions for participants. These included downloading the air quality smartphone app 'AirRater' (completion OR = 1.25, 95 % CI[1.18–1.33]; enrolment OR = 1.11, 95 % CI[1.06–1.16]); using the air quality smartphone app 'AirRater' (completion OR = 1.18, 95 % CI [1.11–1.25]; enrolment OR = 1.07, 95 % CI[1.02–1.12]); developing a bushfire survival plan (completion OR = 1.19, 95 % CI[1.11–1.27]; enrolment OR = 1.12, 95 % CI[1.06–1.17]); and making changes around the home to increase bushfire preparedness (completion OR = 1.10, 95 % CI[1.02–1.19]; enrolment OR = 1.09, 95 % CI[1.03–1.15]). All these actions were strongly recommended in the course. Completion of the course more strongly predicted these actions than enrolment (see Fig. 5b and *S2: Supplementary data Part C* for full results).

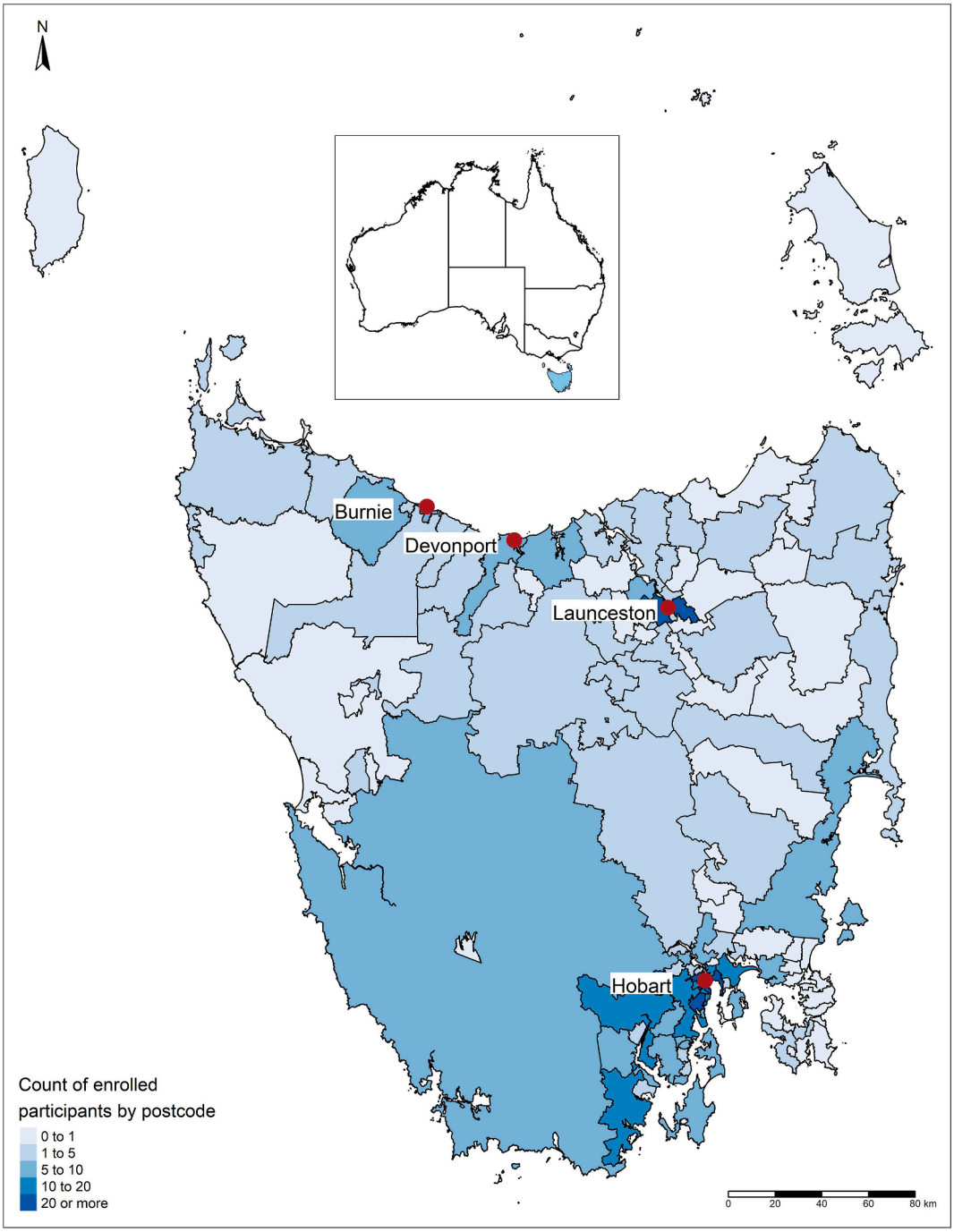

Fig. 2a. Distribution of enrolled course participants by postcode, with Australia map insert.

3.6. Discussion board analysis results

Several themes emerged from analysis of the course discussion board data, which supported and extended the results found from the quantitative analysis, and informed research questions 1, 2 and 3.

Overwhelmingly, participants indicated they enrolled in the course because they wanted to learn more about bushfires, specifically about the mental and physical health impacts, and bushfire preparedness. This expectation was met, with participants engaged in the course learning new information about mental health and recovery processes, health impacts of smoke exposure, the importance of developing a bushfire plan, and the environmental and cultural issues associated with bushfires, against a background of learning something new in an enjoyable way (see Fig. 6). The following sections provide evidence with respect to each of these themes.

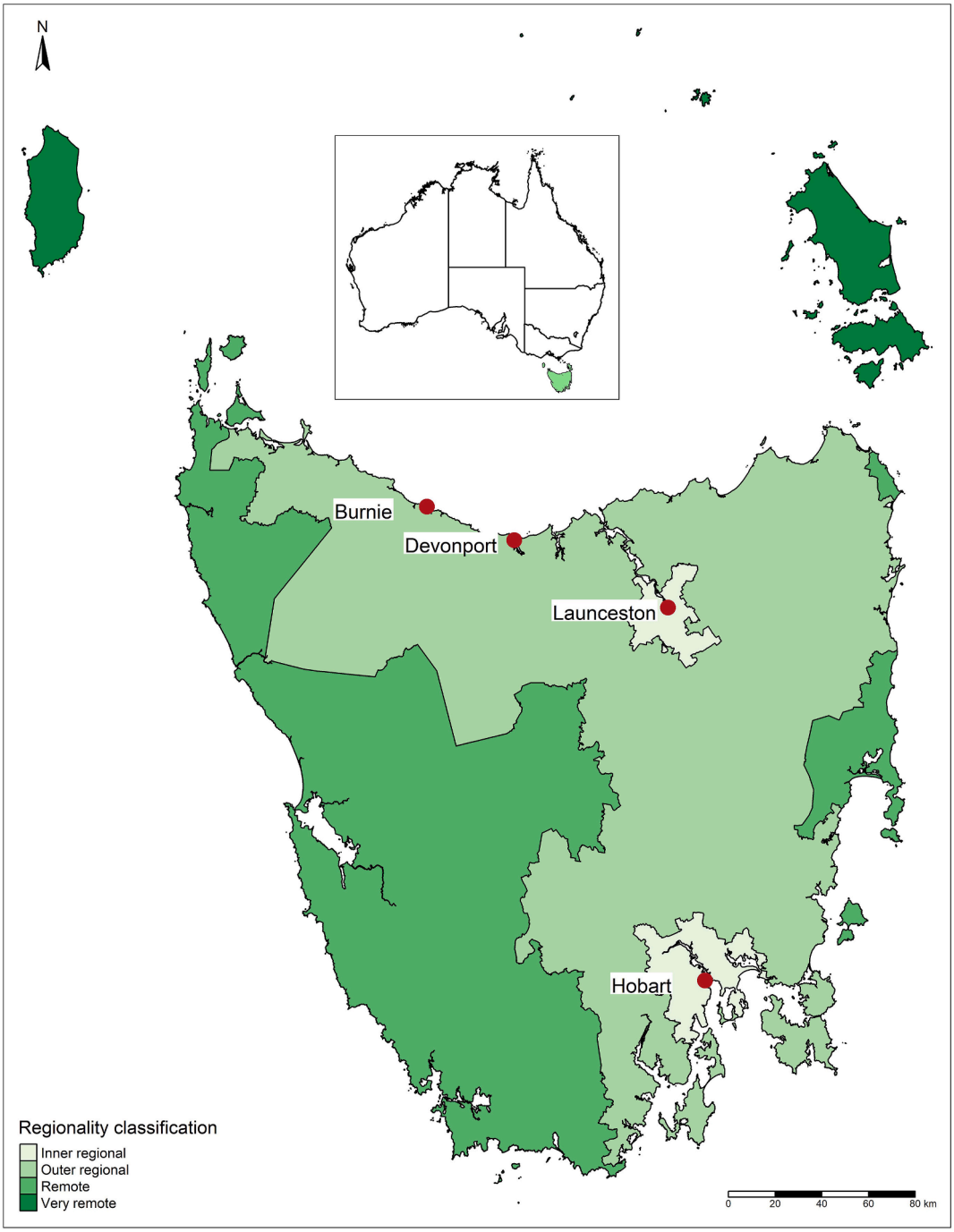

Fig. 2b. Regionality classifications of Tasmania as specified by Australian Bureau of Statistics [21], with Australia map insert.

3.6.1. Participant expectations

3.6.1.1. Wanting to learn about bushfires. Participants stated they enrolled in the course as they were keen to learn and wanted to expand their knowledge about bushfires.

> *I hope to complete it [the course] and increase my knowledge of this topic. As I have very limited understanding of the real impact of bushfires.* (Discussion board 1)

> *I'm really pleased to be able to take this opportunity to learn some more from the Island project. I live in an area of Tassie [Tasmania] with a very high fire rating so I'm sure this course will come in handy, hopefully just to give me more confidence in our beautiful environment.* (Discussion board 1)

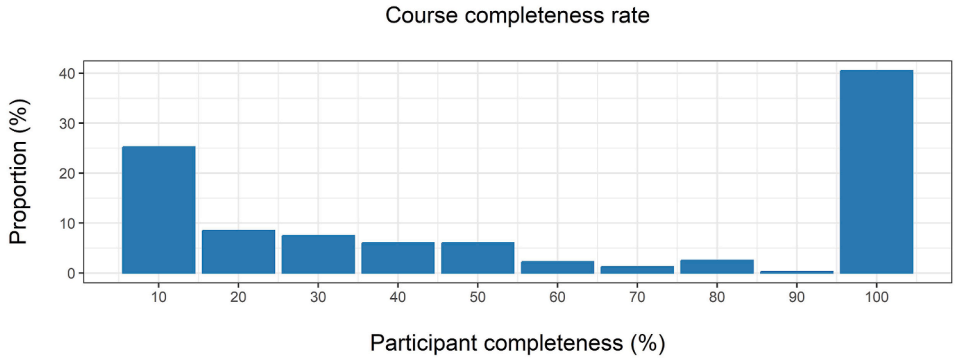

Fig. 3. Course completeness rate.

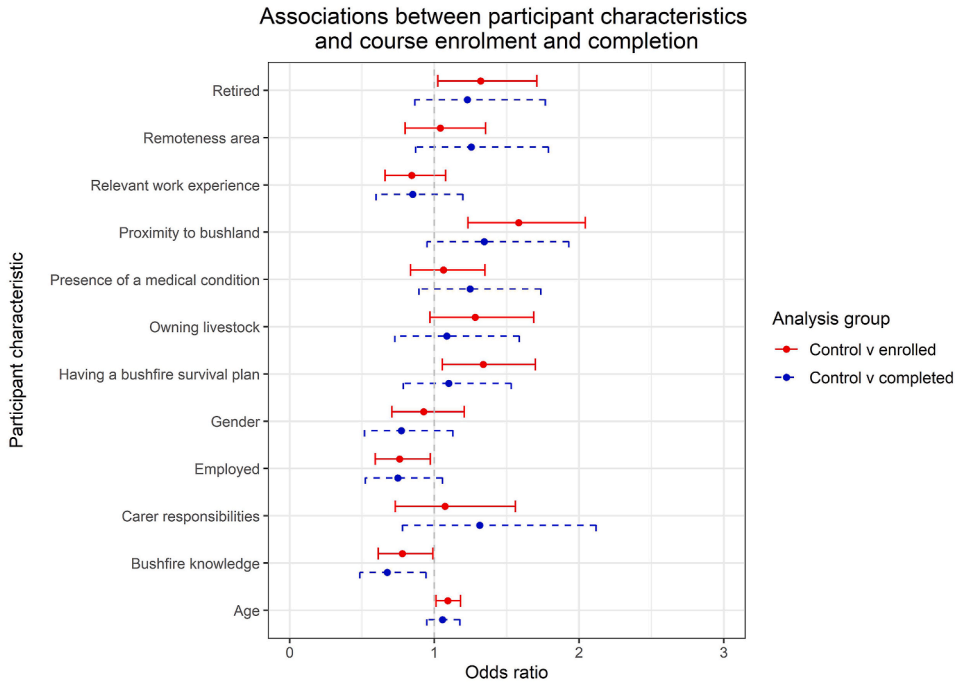

Fig. 4. Associations of various participant characteristics between i) control group and course enrolment and ii) control group and course completion.

3.6.1.2. Physical and mental health impacts. Participants indicated they specifically wanted to learn about the physical and mental health impacts of bushfires and how they could build resilience. Some participants were keen to build on their pre-existing general knowledge.

> *When I think of being surrounded by fire, I am very aware of my heart rate increasing and my nostrils flaring and I start breathing deeply, the thought of a bushfire is very anxiety provoking. I am hoping that this course will help allay some of my fears by assisting me become more prepared.* (Discussion board 1)

> *I am a retired [job title] and have seen the impacts of many factors on respiratory health, I am looking forward to learning more about bushfires and smoke on mental as well as physical effects of bush fire events.* (Discussion board 1)

Other participants indicated the trauma of previous events had spurred them to take the course.

> *We decided to stay and defend our property during the last bushfire in [year]. It was terrifying taking shifts during the night to watch for embers … However, I think the worst for me was at the beginning when I made a dash to [location] to get food … and they refused to let me go back. I fell to bits completely as my husband was on his own with our old dog and there was no telling for how long this would go on. I didn't know what to do and ended up checking in to the evacuation centre along with hundreds of others. They were lovely there, as I was sobbing and so lost and confused … I think that affected me more deeply than anything else, though the weeks of solid smoke I am sure has also had a long-term effect. So, I am doing this course to help prepare me to be in a better state than I was last time - all help would be great!* (Discussion board 1)

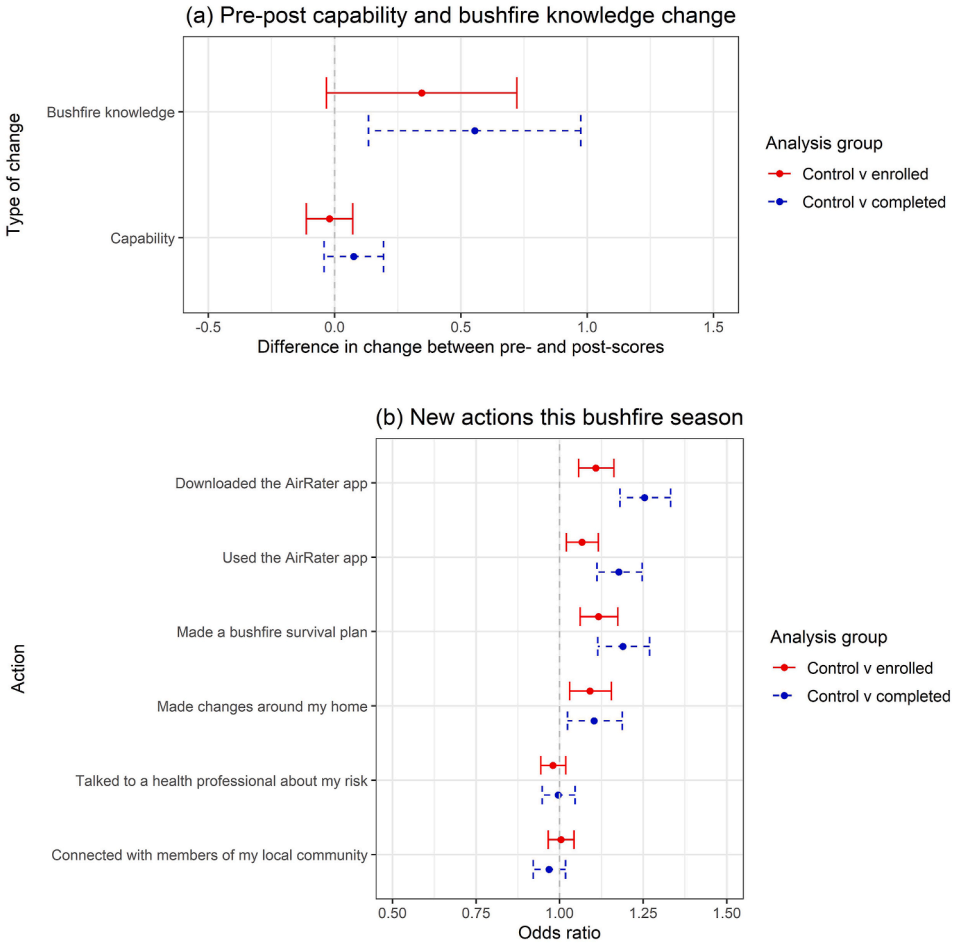

Fig. 5. (a) Pre-post capability and bushfire knowledge change and (b) New actions undertaken since completing or enrolling in the course, analysed between (i) control group and course enrolment and (ii) control group and course completion.

3.6.1.3. Bushfire preparedness. Many participants indicated they were keen to learn how to better prepare for bushfires, especially if their existing knowledge base was low.

> *I am here to increase my knowledge about bushfires and how to be ready should one occur in close proximity to my home. I also hope to learn how to support and assist others affected by bushfires and the key factors relating to prevention and insuring one's own safety.* (Discussion board 1)

> *We live near to [location] in an area of farmland and bush. The fact that our home is surrounded by eucalypts—some of them huge old trees—means that in the event of fire our home would probably be destroyed. At present I have very little idea of what we could do, or where we could go, as we could not stay to defend … I'm hoping to gain a better understanding through this course.* (Discussion board 1)

3.6.2. Participant outcomes

3.6.2.1. Learning something new and enjoyable. Participants described learning new information on a range of topics, and doing so in an enjoyable way.

> *Now totally aware of the far-reaching effects of bushfires, both in the immediate and long term and of the impact on individuals, communities and the environment.* (Discussion board 6)

This is an excellent program; v. glad I followed it. Thank you! (Discussion board 3)
What an enlightening module. (Discussion board 6)

3.6.2.2. Mental health impacts and recovery processes. Engagement with the course led to participants learning about the mental health impacts of bushfires and recovery processes. For example, this participant explains how before undertaking the module they had not considered how bushfires could impact mental health:

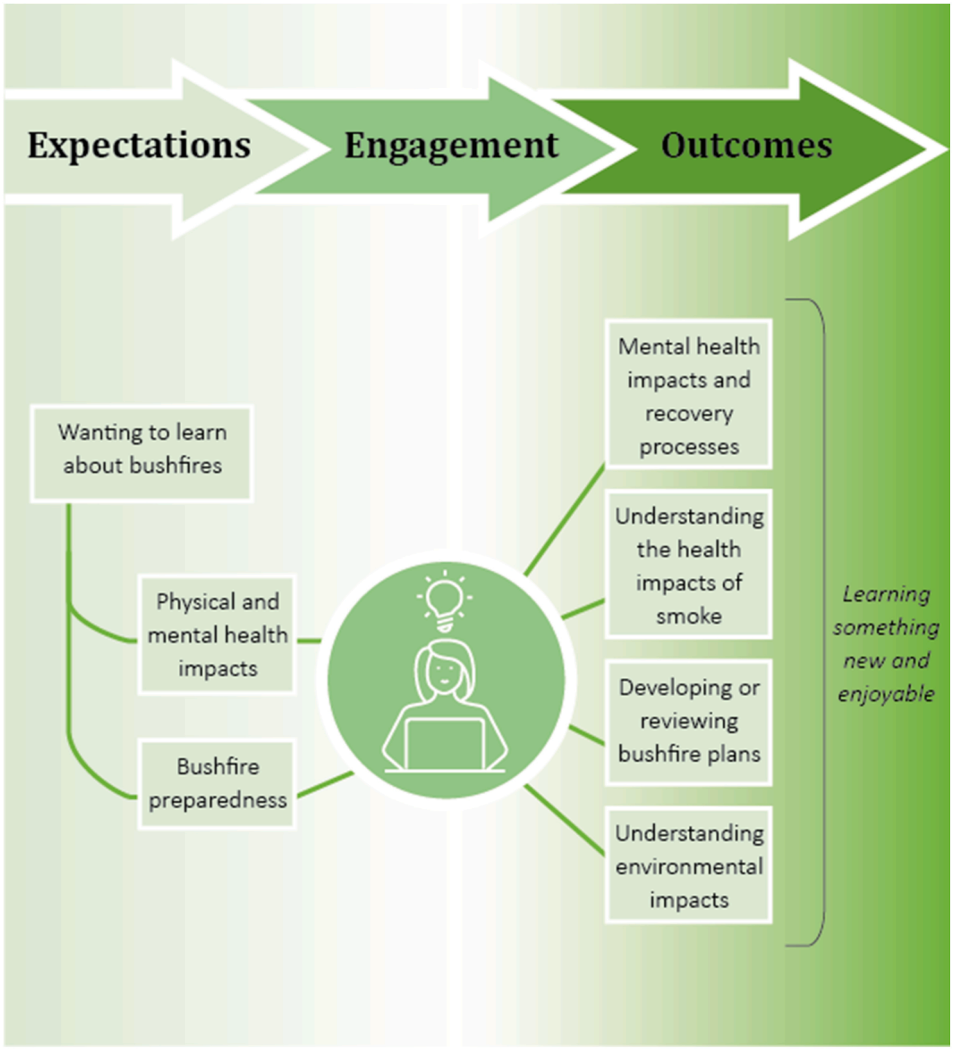

Fig. 6. Discussion board themes showing participant expectations and outcomes as a result of learning engagement.

> *I had not ever considered the impact of fire on anything but the environment, but do now realise that the mental health of people experiencing bushfires and the social impact could lead to on-going problems.* (Discussion board 3)

Specifically, participants gained insight into the recovery process after a fire.

> *This has been very enlightening … The advice can be applied to many areas of my life where I can use these techniques. My brother was stressed after a flood destroyed his home. I can now understand all of the processes that people go through when recovering from disasters and other traumatic events.* (Discussion board 4)

> *I was most surprised about the cycling effect of emotions, and that the periods are predictable. Probably, the key messages for me are the necessity of 'sanity breaks' for retaining/recovering cognitive ability, and the importance of maintaining (and/or acquiring) self-reflection.* (Discussion board 4)

3.6.2.3. Understanding the health impacts of smoke. Many participants acquired new knowledge about the various physical health impacts of smoke.

> *I didn't know about the differences in the way particulate sizes can access the body. It made perfect sense that if the smallest could enter the bloodstream, there may even be some fine enough to cross the blood brain barrier.* (Discussion board 7)

> *I didn't know that smoke inhalation increases the risk of blood clots and rising blood glucose levels. And I suspect that even for healthy people there is a long-term effect of increased smoke in the air over the years as climate change indicates we will experience.* (Discussion board 3)

Learning about the danger of radiant heat was also new information for many participants.

I was surprised that radiant heat (electromagnet radiation) is the greatest bushfire hazard to physical health. (Discussion board 7)

I was very interested to read that radiant heat can affect from 100m, it doesn't go around corners but does penetrate glass. (Discussion board 7)

3.6.2.4. Developing or reviewing bushfire plans. Engagement with the course resulted in participants developing a bushfire plan or reviewing their existing bushfire plans. After doing the course, participants overwhelmingly said they would leave early rather than stay and defend their property in the event of a bushfire.

This [course] has definitely convinced me to leave early and not try to be a martyr. (Discussion board 6)

We will have to leave early I always thought I would stay and protect my home but no. (Discussion board 6)

The risk factors that I have learnt have increased my awareness to leave early from potential bushfires. (Discussion board 6)

A salient prompt to re-assess my [partner's] and my abilities to prepare our property even though it's urban, whether to stay and defend or leave early (definitely now the latter). (Discussion board 6)

3.6.2.5. Understanding environmental and cultural issues. New knowledge was gained around the environmental impacts of bushfires. For example, participants explained how they learnt about the risk of household flammable goods and water pollution.

I will be discussing with [partner] some of the issues of BBQ gas bottles, motor mower fuels, paints and chemical which are stored in the shed. This is so that, in case of fire, we don't go into the shed and endanger ourselves. (Discussion board 6)

The condition of the streams, so loaded with ash and debris that they looked like concrete being poured surprised me most. This really brings home how dangerous and unliveable our environment will become. (Discussion board 6)

Some participants noted the importance of cultural burns to manage bushfire risk.

Like others doing this course, I am surprised that so little is done by way of cultural burns. I would have thought that this knowledge would be valuable to rural fire brigades as well as fire authorities in [location] (which is one of the most fire-prone cities anywhere in the world). Maybe such burns are taking place - if so, there is very little publicised about them. (Discussion board 3)

Cultural burns are a good way to manage the landscape once the heavy fuel loads are eliminated, usually by bush fire or planned hazard reduction burns. Cultural fire practice could possibly be used more often by the fire services. It is not a secret on how its carried out and can be taught to firefighters. (Discussion board 3)

4. Discussion

Our findings show that engagement with an online short course has the potential to help participants understand the health implications of exposure to bushfires and bushfire smoke for their individual circumstances. Course information appears to enable participants to make active and relevant changes to reduce their exposure and health risks for both bushfires and bushfire smoke. Course completion appears to improve preparation and response engagement compared to course enrolment alone.

4.1. Strengths and limitations of the study

A strength of our study is the mixed methods approach, which allows the qualitative analysis to provide a greater context and understanding to the quantitative analysis [31]. For example, a strong theme of the discussion board analysis centred on how course engagement encouraged users to develop or review their bushfire survival plans, a key concept in bushfire survival. This theme was also highlighted in the quantitative analysis, where results showed that completing a bushfire survival plan was 9 % more likely if a participant had enrolled in the course, and 19 % more likely if they had completed the course, compared to those who did not enrol in the course. The mixed methods approach also allowed insight into highly relevant themes where quantitative data was not available, for example, participants reflections on the value of cultural burning practices, and nuances of mental health impacts and the differences in individual recovery processes.

Our study also benefits from access to a control group who did not undertake the course, but who are highly comparable across sociodemographic variables (see Table 1). This enables clear analysis of course enrolment and completion associations. Based on Claflin et al. [40] this does not appear to be a usual or common methodology for online course evaluation, yet provides a rich insight into the potential drivers of enrolment and completion, and for undertaking relevant actions post-course completion.

There are some limitations with our analysis that may hinder further extrapolation and/or generalisation. Firstly, the profile of those recruited into the ISLAND Project show participants are highly educated when compared to the general Tasmanian population [30], and by definition, course participants have highly accessible and reliable internet coverage. Further, as our pilot cohort is adults over 50 years of age residing in Tasmania, there may be considerations when generalising these findings to a broader population and location. Secondly, we did not seek to measure how information gained in the course was retained over time, nor if bushfire-related actions undertaken after the course were continued or expanded into the future, when compared to the control group. Future iterations of the ISLAND Resilience Initiative have the potential to investigate this issue. Thirdly, we recognise the measures reported in this study are self-reported, making our results open to self-reporting bias. Finally, the need to minimise participant burden limited the number of factors it was possible to assess. This means there may be other factors not identified in pre-post surveys that influence course enrolment and completion.

4.2. Policy and practice implications

While online courses across a broad range of topics have been well evaluated [40], there appears to be a paucity of literature covering the evaluation of online course material for bushfires and smoke, or for online courses covering the health impacts of other extreme events such as floods, cyclones or heatwaves. This is despite consistent calls from researchers for community-based education regarding these events to enable increased resilience [41,42]. Of note, Breuer and colleagues examined the potential for game-based learning scenarios in flood management, concluding there are a number of substantial considerations that need to be addressed before this technology is useful [43]. In addition, Rothkrantz examined the potential for a game-like Massive Open Online Course for responding in flood emergencies, also concluding there are a number of difficulties and refinement needed to further implement this tool effectively [44].

Our evaluation, however, shows that a relatively simple educational approach is useful, at least in the context of protecting health from bushfires and bushfire smoke exposure. Our results demonstrate participants had high engagement with the course material, and were up to five times more likely to complete the course compared to typical completion rates for online education [45]. Our results also indicate that participants more engaged in the course (i.e., having consumed more course material), are more likely to adopt new actions to protect health. The capacity of our course to achieve these outcomes aligns with de Freitas et al. [45], who suggest course design principles such as social interactions, interactive assignments, accessibility options, variations in learning style and participant self-reflection, would appear to be essential in securing and supporting positive course outcomes and completion rates.

Our results also point to how these types of courses may be best promoted or marketed to reach those who potentially have the greatest need for information. Course enrolment and completion were inversely associated with poor bushfire knowledge, indicating that those with prior existing or enhanced knowledge of bushfires were more likely than the control group to enrol and complete the course. Strategies to promote the course in innovative ways, and therefore reach populations less likely to have prior existing knowledge, deserve further exploration (see Section 4.3).

This research has significance for the emergency management field, especially policymakers and practitioners with a commitment to developing methods to increase community resilience regarding extreme events. Identification of the factors impacting enrolment and completion are also invaluable in marketing and retention efforts of future courses.

4.3. Future directions and research

During the Australian summer of 2022-23, this course was made available to a wider group of participants through the University of Tasmania online short course portal (www.utas.edu.au/study/short-courses). Critical course information was also developed and translated into multiple languages and made available as written fact sheets and as audio files to members of several language groups through local humanitarian services. These languages represent communities most recently arrived in Tasmania with a lower level of English literacy, and include Nepali, Arabic, Oromo, Farsi, Karen and Tigrinya. This additional material was developed in the context that culturally and linguistically diverse groups are less likely to receive or understand emergency messaging and are therefore highly vulnerable [46]. The 2023–2024 Australian summer will also see the course material updated to have improved national content, and be marketed to a national audience. Future iterations of the course could potentially expand the breadth of translation options and make the course more widely available to other vulnerable communities who have little understanding of the risks involved with bushfires and bushfire smoke, and are not widely considered in public health communications about such events [47].

Future research could potentially focus on the longer-term impact of engaging with the course, especially in understanding factors associated with new actions and increased knowledge retention. Additional funding may enable this research in the future.

5. Conclusion

Community education, such as an online short course, has the potential to increase participant knowledge and proactive preparedness actions in managing and living with bushfires and bushfire smoke. These actions may serve to reduce smoke exposure and therefore promote health at times of poor air quality from bushfire events.

Author contribution statement

SC: conceptualisation; data analysis; writing and editing manuscript; JB: data analysis; editing manuscript; CA: data analysis; editing manuscript; MZ: data analysis; editing manuscript; DS: data management; supervision; editing manuscript; FJ: conceptualisation; supervision; editing manuscript; PJ: conceptualisation; editing manuscript.

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

The data that has been used is confidential.

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Appendix A. Supplementary data

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