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Research Article

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# Predictors of itch and pain in the 12 months following burn injury: results from the Burns Registry of Australia and New Zealand (BRANZ) Long-Term Outcomes Project

**Lincoln M. Tracy[1,*], Dale W. Edgar[2,3], Rebecca Schrale[4], Heather Cleland[5], and Belinda J. Gabbe[1,6] on behalf of the BRANZ Adult Long-Term Outcomes Pilot Project participating sites and working party**

[1]School of Public Health and Preventive Medicine, Monash University, 553 St Kilda Road, Melbourne, Victoria, 3004, Australia [2]State Adult Burn Unit, Fiona Stanley Hospital, 11 Warren Drive, Murdoch, Western Australia, 6150, Australia [3]Burn Injury Research Node, The University of Notre Dame, 19 Mouat Street, Fremantle, Western Australia, 6959, Australia [4]Tasmanian Burns Unit, Burns & Surgical Specialties Unit 5A, Royal Hobart Hospital, GPO Box 1061, Hobart, Tasmania, 7001, Australia [5]Victorian Adult Burns Service, The Alfred, Commercial Road, Melbourne, Victoria, 3004, Australia [6]Health Data Research UK, Swansea University Medical School, Swansea University, Singleton Park, Swansea, Wales SA28PP, United Kingdom

*Correspondence. Email: lincoln.tracy@monash.edu or dr.lincoln.m.tracy@gmail.com

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## Abstract

**Background:** Itch and pain are common complaints of patients with burn injuries. This study aimed to describe the prevalence and predictors of itch and moderate to severe pain in the first 12 months following a burn injury, and determine the association between itch, moderate to severe pain, work-related outcomes, and health-related quality of life following a burn injury.
**Methods:** Burn patients aged 18 years and older were recruited from five Australian specialist burn units. Patients completed the 36-item Short Form Health Survey Version 2 (SF-36 V2), the Sickness Impact Profile (SIP) work scale, and a specially developed questionnaire relating to itch at 1, 6, and 12 months post-injury. Moderate to severe pain was defined as a score less than 40 on the bodily pain domain of the SF-36 V2. Multivariate mixed-effects regression models were used to identify patient and burn injury predictors of itch and moderate to severe pain.
**Results:** Three hundred and twenty-eight patients were included. The prevalence of itch decreased from 50% at 1 month to 27% at 12 months. Similarly, the prevalence of moderate to severe pain decreased from 23% at 1 month to 13% at 12 months. Compared to patients aged 18-34, the adjusted odds of experiencing any itch were 59% (95% CI: 0.20, 0.82) and 55% (95% CI: 0.22, 0.91) lower for patients aged between 35 and 49 and $\geq$ 50 years, respectively. Compared to patients aged 18-34, the adjusted odds of experiencing moderate to severe pain were 3.12 (95% CI: 1.35, 7.20) and 3.42 (95% CI: 1.47, 7.93) times higher for patients aged 35-49 and $\geq$ 50 years, respectively.
**Conclusions:** Less than 15% of patients reported moderate or severe pain at 12 months, while approximately one-quarter of the patients reported itch at the same period. The presence of moderate to severe pain was associated with a greater negative impact on health-related quality of life and work outcomes compared to itch. Further research is needed to improve our ability to

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identify patients at higher risk of persistent itch and pain who would benefit from targeted review and intervention studies.

**Key words:** Burn registry, Outcomes, Cohort study, Pain, Itch, Australia, New Zealand, Predictor

## Background

Burn injuries have a broad impact on the lives of patients. Along with fatigue [1, 2], itch and pain are common complaints from patients following burn injury, resulting in disturbances to work, sleep, and social activities [3]. Various studies have proposed different prevalence rates for itch following burn injury, ranging from 57% to 100% of patients [4]. Previous studies suggest that itch following burn injury usually peaks in the initial months following the closure of the wound, before resolving in the following months [5, 6]. Establishing the level of pain experienced by burn patients is challenging, as pain in burn patients varies greatly from patient to patient and shows substantial variation over time [7]. Consequently, few studies examine long-term pain outcomes in burns patients. In their study of 104 burn survivors, Choinière et al. reported that 35% of survivors reported burn-related pain up to 7 years post-injury [8], and Malenfant et al. reported that 36% of the 236 burn injury survivors in their study experienced persistent pain up to 7 years post-injury [9]. Dauber et al., who studied 358 individuals attending a burn survivor support group, reported that 52% of attendees experienced persistent pain up to 12 years post-injury [10]. More recently, Browne et al., in their study examining long-term pain and psychological outcomes in 492 burn survivors, reported that 18% of survivors experienced persistent burn-related pain [11].

In addition to the range of studies that have described the prevalence of itch and pain following burn injury, there have been a number of studies that have sought to identify risk factors or predictors of ongoing itch/pruritus and pain. However, these studies had limitations, including not undertaking statistical analysis to identify risk factors [12, 13], only collecting data from a single site or country [14, 15], only collecting follow-up data at one time point [14], or not having chronic or ongoing itch and/or pain as the key outcome of interest [11]. In addition, while Carrougher et al. undertook a comprehensive investigation of self-reported pruritus [16], this cohort of burns patients was enrolled through the United States National Institute on Disability and Rehabilitation Research Burn Model System. This system collects data on adult burns patients with severe burn injuries [16, 17], and therefore does not represent the broader burn patient population in Australia and New Zealand, where burn injuries are typically less severe in terms of burn size [18]. Therefore, comparing findings between study populations is difficult.

Identifying the frequency of itch and pain following burn injury, how they change over time, the kind of patients who encounter issues with itch and pain, and the extent to which itch and pain interfere with return to work following burn injury is needed to improve how well we understand the burden of burn injuries. Enhancing our understanding of the burden of burn injuries will improve the clinical care of burn patients. The aims of this prospective, multicenter study were to: (i) describe the prevalence and predictors of itch and moderate to severe pain (defined as a score less than 40 on the bodily pain domain of the Short-Form Health Survey Version 2 (SF-36 V2)) in the first 12 months following burn injury, and (ii) establish the associations between itch, moderate to severe pain, work outcomes, and health-related quality of life following a burn injury.

## Methods

### Study setting

The populations of Australia (23.4 million) and New Zealand (4.5 million) are served by 17 burn units that provide specialist burn care services. In July 2009, the Bi-National Burns Registry (Bi-NBR) was launched as a clinical quality registry designed to collect epidemiological, quality of care, and outcome data for adult and pediatric burns patients across Australia and New Zealand. The Bi-NBR was rebranded as the Burns Registry of Australia and New Zealand (BRANZ) in 2012. Approximately 3000 novel inpatient admissions are recorded by the BRANZ each year. All admissions presenting to a specialist burns unit within 28 days of injury (where a burn is the principal reason for admission) are recorded by the BRANZ. These admissions are recorded on the provision that the patient is (a) admitted to hospital for more than 24 hours, (b) admitted to hospital for less than 24 hours but requires a burn management procedure in theater, or (c) admitted to hospital and dies within 24 hours. Admissions that do not meet these criteria and desquamating skin conditions are not included in the BRANZ.

### Study participants

Burns patients aged 18 years and older who met the BRANZ inclusion criteria (but survived to discharge) were sequentially recruited from one of five specialist Australian burns units for this study [19].

### Procedures

The complete project methodology is described elsewhere [19, 20]. Therefore, only a brief summary is provided here. Participants were recruited between October 2009 and December 2010, predominantly during their inpatient stay. As this was purely an observational study, the five participating sites did not make any changes to their burn care protocols.

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Participants were followed-up at 1, 6, and 12 months post-injury by in-person interview, a self-administered questionnaire that was mailed out to participants, or an interview completed via telephone. Itch was measured using questions developed by the BRANZ Long-Term Outcomes (LTO) Working Party in the absence of validated instruments at the time of development of the study [20]. The specially developed itch questionnaire included two questions to measure the frequency of experiencing itch (ranging from "none of the time" to "all of the time") and the intensity of the experienced itch (ranging from "none" to "very severe") on five-point Likert scales. The itch questionnaire also measured the perceived interference of itch across six domains (general activity, mood, walking ability, normal work, relationships with other people, and enjoyment of life) on 11-point Likert scales (ranging from "0—does not interfere" to "10—completely interferes"; [20]).

The SF-36 V2 and the work and recreation scale of the Sickness Impact Profile (SIP) were completed as measures of generic health status at each follow-up interview [21–27]. The SF-36 V2 is a 36-item self-report questionnaire designed to measure health status over eight domains: physical functioning, physical role, bodily pain, general health, energy/vitality, social functioning, and general concepts of physical and mental health [22, 24–27]. It has previously been validated for use in burns [28]. The work and recreation scale is one of 12 SIP scales. It contains nine items about return to work and work-related disability and can be used independently of the other 11 scales [21, 23]. Higher scores on the work and recreation SIP scale represent greater levels of work-related disability.

The following data were extracted from the BRANZ to describe patient characteristics: patient demographics (age, gender, socioeconomic status, and geographic remoteness), burn injury and severity details (primary cause, burn size, burn depth, and inhalation injury status), burn management details (admission to theater, skin grafting), and in-hospital outcomes (intensive care unit (ICU) admission and length of stay (LOS)). Residential postcodes of participants were mapped to the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), a measure of socioeconomic conditions [29], and the Accessibility/Remoteness Index of Australia (ARIA), a measure of geographic remoteness [30].

### Statistical analysis

Statistical analyses were performed in Stata Version 14 (StataCorp, College Station, TX, USA) and the R statistical environment version 3.6.1 [31]. The overall profile of participants was described using summary statistics as appropriate (i.e., frequencies and percentages for categorical variables; mean and standard deviation (SD) or median and interquartile range (IQR) as appropriate for continuous variables). Mann–Whitney *U* tests compared the itch and pain groups at each follow-up interview for the SF-36 V2 component summary scales and scores and the SIP work and recreation scale. Spearman's rho assessed correlations between the itch and pain scores and the subscales of the SF-36 V2.

Two outcomes of interest were defined for this study. The first outcome was itch, which was defined as a global itch score greater than zero on the questionnaire developed by the BRANZ LTO Working Party [20]. The second outcome was moderate to severe pain, which was defined as a score less than 40 on the bodily pain domain of the SF-36 V2. The definition of the latter outcome is comparable with previous definitions of moderate to severe pain [32, 33]. This definition is also similar to the previously used definition for moderate to severe fatigue following burn injury [19]. Missing data were minimal, as stated elsewhere [19]. It was assumed that the data was missing at random (MAR) and multiple imputation by chained equations (MICE) created ten multiple imputed data sets to identify missing values [34–36]. Patient age and gender, the primary burn cause, burn size and depth, ARIA and IRSAD values, LOS, admission to theater, and inhalation injury status were included in the MICE analysis. The log (odds ratio [OR]) estimated from each of the ten imputed data sets were combined to create a singular and robust odds ratio as per the rules of Rubin [37].

Mixed-effects logistic regression modeling was used to determine demographic, socioeconomic, and burn injury (i.e., the primary cause, burn size, and depth) predictors of itch and pain at follow-up. This type of modeling was used to account for the missing data from repeated measurements of a confined set of participants. Univariate models were first tested to identify single predictors of itch and pain. Predictors displaying an association (i.e., $p < 0.20$) with itch or pain were then tested in the multivariable model, for which adjusted ORs and corresponding 95% confidence intervals (CIs) are reported.

## Results

### Participant characteristics

As previously described, 328 patients completed at least one follow-up as part of the study with the number of patients participating declining as the study progressed (19). Reasons and predictors of loss to follow-up have been discussed elsewhere [19, 20]. The characteristics of patients included in this study is reported in Table S1.

### Interference with activities due to itch

Itch interfered with all activities the most at 1 month, but the level of interference decreased over time (Fig. 1). Itch interfered with mood, general activity, and enjoyment of life more than with relationships and walking ability (Fig. 1).

### Prevalence, frequency, and intensity of itch and pain

The prevalence of itch decreased from 50% ($n = 146$) at 1 month to 34% ($n = 75$) at 6 months and 27% ($n = 49$) at 12 months. The patients experiencing itch reported lower ($p < 0.05$) SF-36 V2 summary scores for mental and physical health (Figs 2a, b). Patients experiencing itch had lower SF-36

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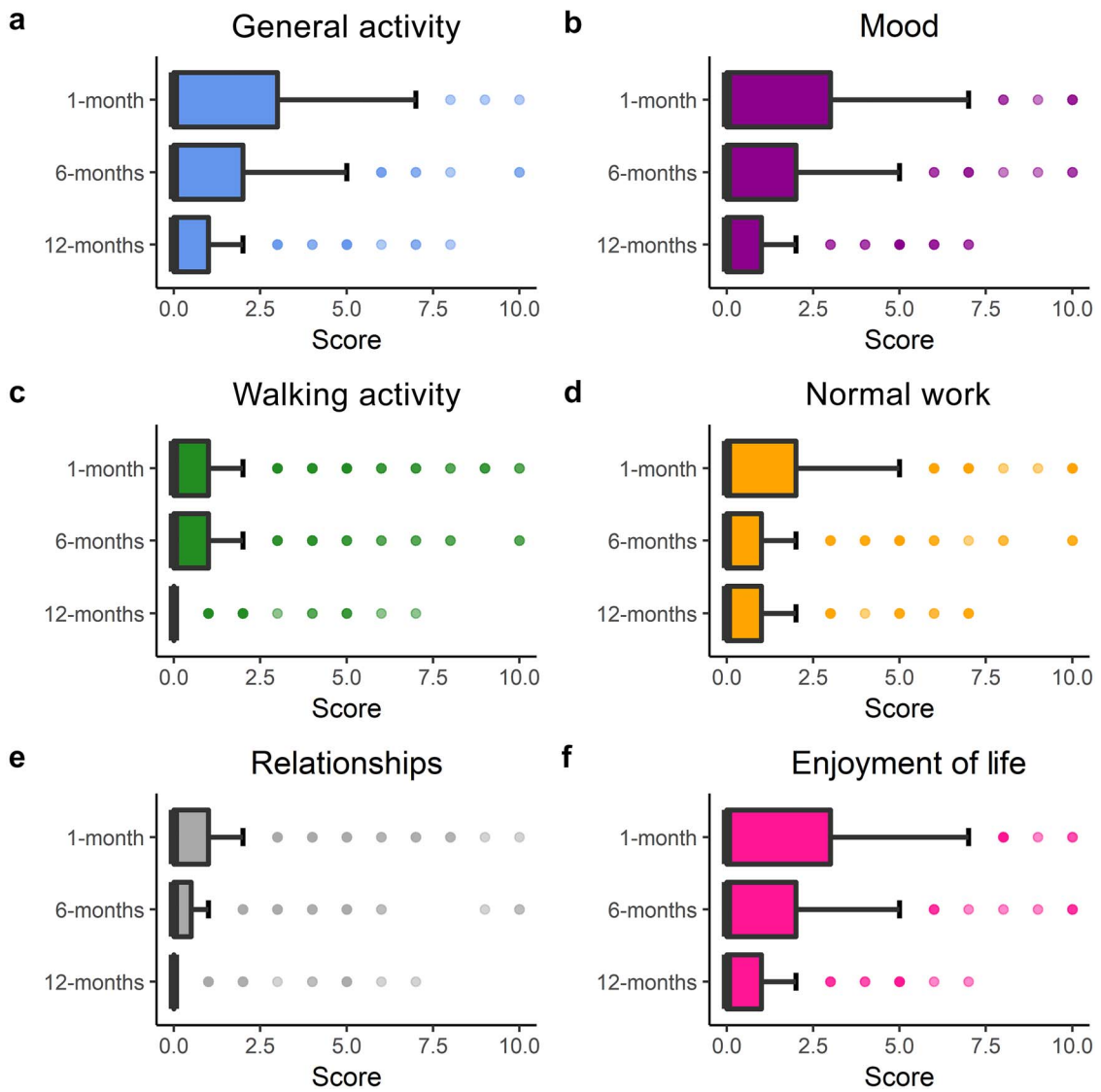


**Figure 1.** Scores for the level of interference on the domains of the specially developed itch questionnaire, (**a**) general activity, (**b**) mood, (**c**) walking activity, (**d**) normal work, (**e**) relationships and (**f**) enjoyment of life. Higher scores represent a greater level of interference on each domain

V2 summary scores than the population mean of 50 at each time point, while itch-free patients had SF-36 V2 summary scores above the population mean of 50 (Figs 2a, b).

The mean ± SD frequency of itch was 3.1 ± 1.0 at 1 month, before increasing to 3.5 ± 1.2 at 6 months and 3.9 ± 1.2 at 12 months. The mean ± SD intensity of itch was 3.3 ± 1.1 at 1 month, before falling to 2.8 ± 1.2 at 6 months and 2.6 ± 1.2 at 12 months. Higher scores represent a higher frequency (i.e., more frequent) and greater intensity of itch.

The mean scores for each SF-36 V2 domain was lower ($p < 0.05$) for patients reporting itch at each follow-up time point (Fig. 3), except for the general health domain at the 1-month follow-up. Patients experiencing itch had lower SF-36 V2 domain scores than the population mean of 50 at each time point, while itch-free patients had SF-36 V2 domain scores above the population mean of 50 (Fig. 3). The global itch score showed a moderate negative relationship with the subscales of the SF-36 V2 at each follow-up time-point (Figs S1–S3).

The prevalence of moderate to severe bodily pain decreased from 23% ($n = 66$) at 1 month to 17% ($n = 36$) at 6 months and to 13% ($n = 23$) at 12 months. At each follow-up the patients reporting moderate to severe bodily pain reported lower ($p < 0.001$) mean SF-36 V2 summary scores for both physical and mental health (Figs 2c, d). Patients experiencing moderate to severe bodily pain had lower SF-36 V2 summary scores than the population mean of 50 at each time point, while pain-free patients had SF-36 V2 summary scores above the population mean of 50 (Figs 2a, b).

The mean ± SD bodily pain score was 48.1 ± 10.9 at 1 month, which increased to 51.9 ± 11.3 at 6 months and 53.7 ± 9.8 at 12 months. Higher scores represent a higher level of functioning and, therefore, a lower level of pain.

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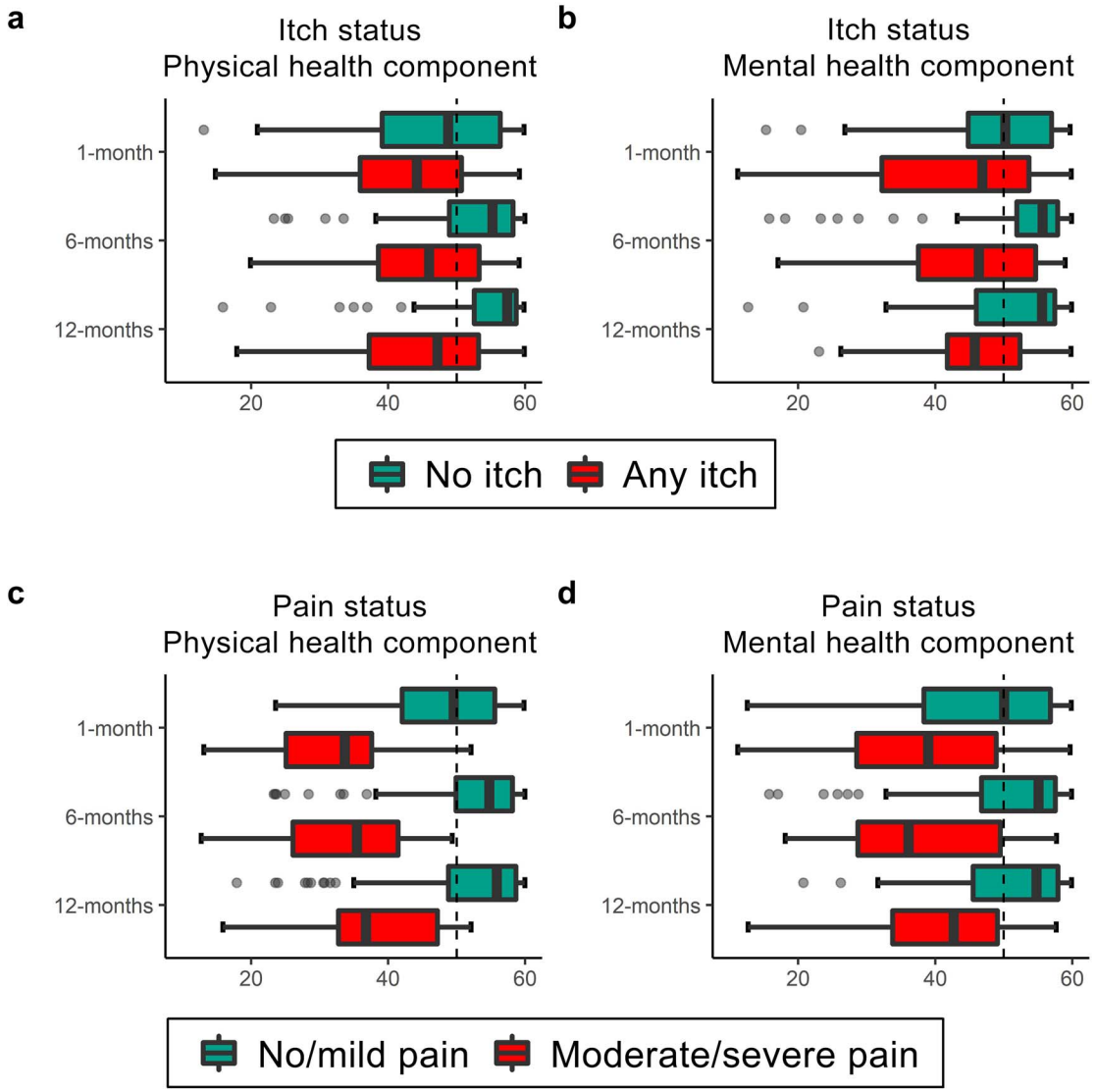


**Figure 2.** Short-Form Health Survey Version 2 (SF-36 V2) component scores following burn injury. Higher scores represent a higher level of functioning. (**a**) SF-36 V2 Physical Health Component scores by whether or not patients reported experiencing itch at each follow-up time point. (**b**) SF-36 V2 Mental Health Component scores by whether or not patients reported experiencing itch at each follow-up time point. (**c**) SF-36 V2 Physical Health Component scores by whether or not patients reported experiencing moderate/severe pain at each follow-up time point. (**d**) SF-36 V2 Mental Health Component scores by whether or not patients reported experiencing moderate/severe pain at each follow-up time point. The dashed line serves as a reference to the population norm of 50 for the SF-36 V2 component scores

The mean scores for each SF-36 V2 domain was lower ($p < 0.001$) for patients reporting moderate to severe bodily pain at each follow-up (Fig. 4). Patients experiencing moderate to severe bodily pain had lower SF-36 V2 domain scores than the population mean of 50 at each time point, while pain-free patients had SF-36 V2 domain scores above the population mean of 50 (Fig. 4). The bodily pain subscale of the SF-36 V2 showed a strong positive relationship with the remaining subscales of the SF-36 V2 at each follow-up time-point (Figs S1–S3).

### Itch, pain, and return to work status

As previously reported, 82% of participants were working for income prior to sustaining their burn injury [19]. Regardless of itch and pain status, the proportion of patients who returned to work increased from 57% ($n = 76$) at 1 month to 89% ($n = 97$) at 6 months and 91% ($n = 83$) at 12 months. Patients with and without itch did not differ in return to work rates at 1 month (52% vs. 58%, $p = 0.45$), 6 months (90% vs. 89%, $p = 0.94$), or 12 months (86% vs. 89%, $p = 0.74$). There were no differences in the median (IQR) SIP work score scales between patients with and without itch at 1 month (66.4 (9.7–70.1) vs. 23.9 (0–70.1), $p = 0.16$) and 12 months (9.7 (0–40.4) vs. 0.0 (0–10.7), $p = 0.26$). Patients with itch reported a higher median SIP work scale score at 6 months compared to patients without itch (10.7 (0–41.7) vs. 0.0 (0–8.3), $p = 0.02$). A smaller portion of patients with pain had returned to work at 1 month (22% vs. 66%, $p < 0.001$)

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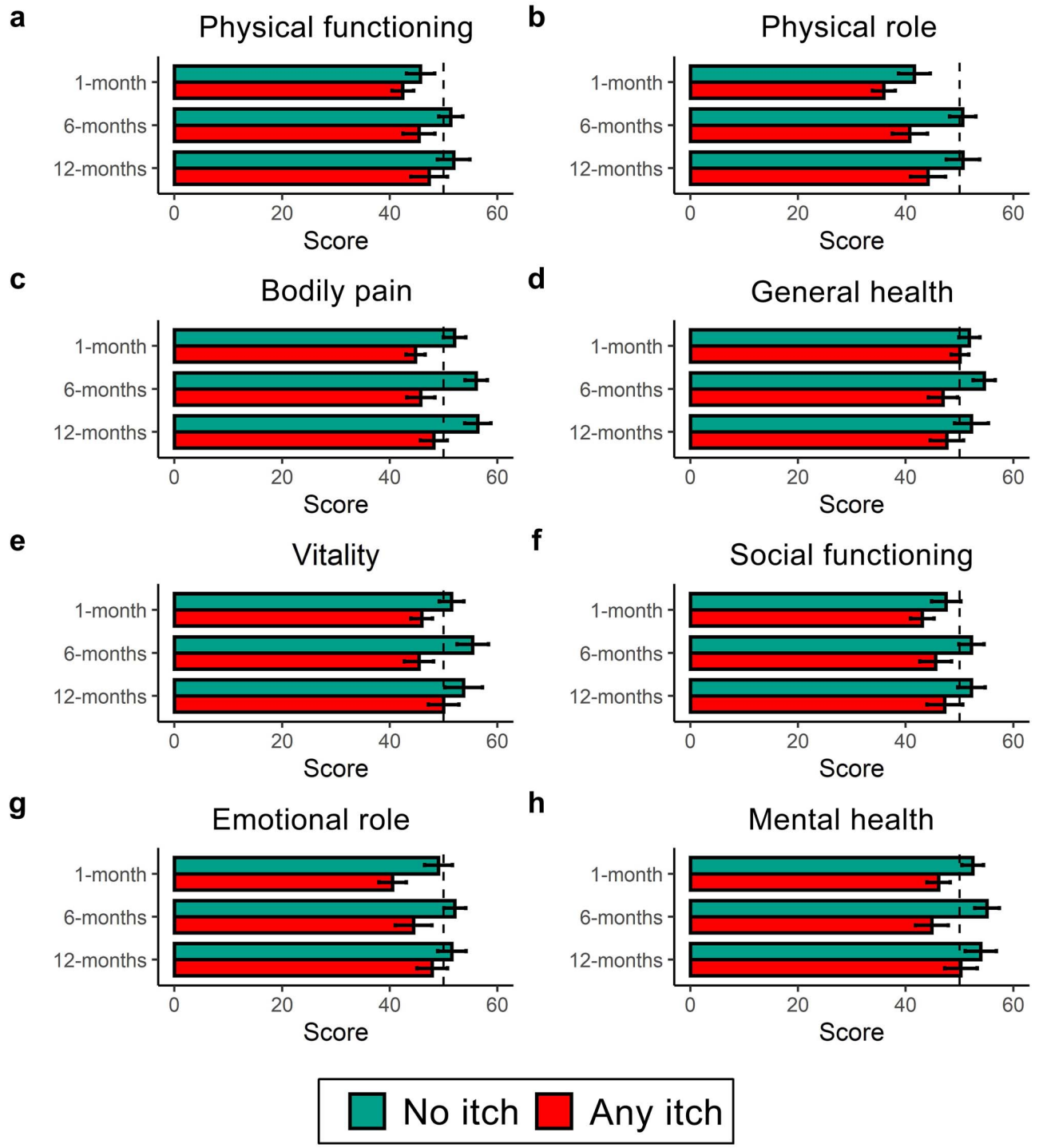


**Figure 3**. Short-Form Health Survey Version 2 (SF-36 V2) domain scores following burn injury by whether or not patients reported experiencing itch at each follow-up time point. Higher scores represent a higher level of functioning. (**a**) SF-36 V2 Physical Functioning domain. (**b**) SF-36 V2 Physical Role domain. (**c**) SF-36 V2 Bodily Pain domain. (**d**) SF-36 V2 General Health domain. (**e**) SF-36 V2 Vitality domain. (**f**) SF-36 V2 Social Functioning domain. (**g**) SF-36 V2 Emotional Role domain. (**h**) SF-36 V2 Mental Health domain. Data presented as mean ± 95% confidence interval. The dashed line serves as a reference to the population norm of 50 for the SF-36 V2 component scores

and 12 months (63% vs. 94%, $p = 0.003$). Patients with and without pain did not differ in return to work rates at 6 months (75% vs. 90%, $p = 0.10$). Participants reporting moderate to severe bodily pain reported higher median SIP work scale scores, indicating greater work-related disability, at 1 month (70.1 (70.1–70.1) vs. 18.1 (0–70.1), $p < 0.001$), 6 months (44.5 (5.3–69.1) vs. 0.0 (0–12.0), $p = 0.004$), and 12 months (12.8 (9.7–70.1) vs. 0.0 (0–8.3), $p = 0.002$).

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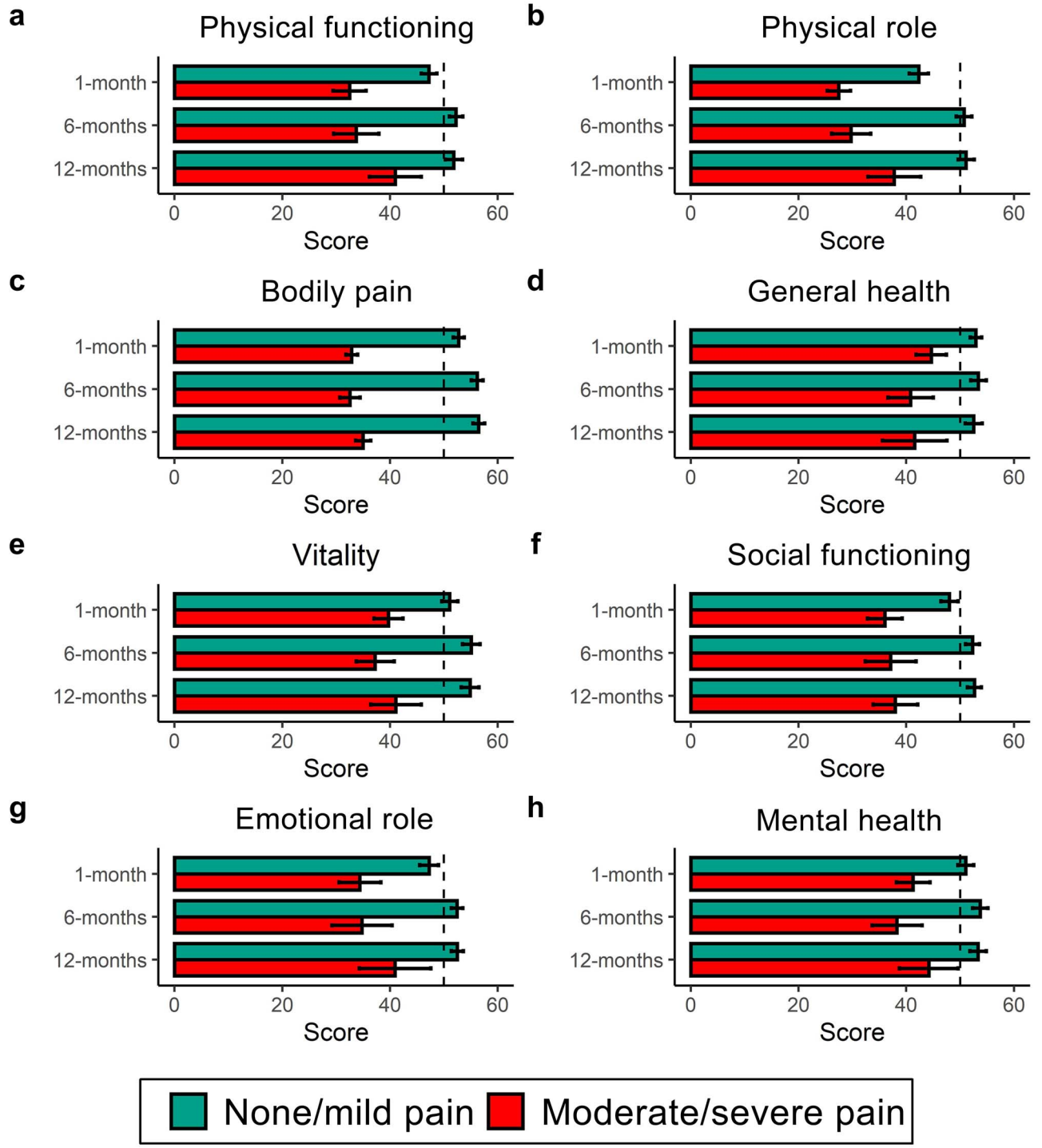


**Figure 4.** Short-Form Health Survey Version 2 (SF-36 V2) domain scores following burn injury by whether or not patients reported experiencing moderate/severe pain at each follow-up time point. Higher scores represent a higher level of functioning. (**a**) SF-36 V2 Physical Functioning domain. (**b**) SF-36 V2 Physical Role domain. (**c**) SF-36 V2 Bodily Pain domain. (**d**) SF-36 V2 General Health domain. (**e**) SF-36 V2 Vitality domain. (**f**) SF-36 V2 Social Functioning domain. (**g**) SF-36 V2 Emotional Role domain. (**h**) SF-36 V2 Mental Health domain. Data presented as mean ± 95% confidence interval. The dashed line serves as a reference to the population norm of 50 for the SF-36 V2 component scores

### Predictors of itch

The characteristics of patients with and without itch at 1, 6, and 12 months are presented in Table 1. Table S2 shows the complete output of the univariable predictor testing for itch. Time since injury ($p = 0.005$), patient age ($p = 0.006$), the percentage of total body surface area affected by the burn (%TBSA; $p = 0.08$), and burn cause ($p = 0.038$) were associated with itch in univariable testing and were subsequently entered into the multivariable model (Table 2).

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**Table 1.** Profile of participants by itch group at each time point post-injury

| Characteristic | 1-month | | 6-months | | 12-months | |
|---|---|---|---|---|---|---|
| | No itch (n = 98) | Any itch (n = 146) | No itch (n = 81) | Any itch (n = 75) | No itch (n = 57) | Any itch (n = 49) |
| Age, mean (95% CI), years | 46.2 (42.8, 49.6) | 39.4 (36.8, 42.0) | 46.1 (47.8, 49.4) | 42.1 (38.2, 46.1) | 45.9 (42.0, 49.7) | 47.4 (42.0, 52.8) |
| Gender, % (95% CI) | | | | | | |
| Female | 31.3 (22.0, 40.5) | 32.9 (25.2, 40.6) | 34.1 (23.7, 44.6) | 29.3 (18.9, 39.8) | 32.8 (20.4, 45.1) | 32.7 (19.2, 46.1) |
| Male | 68.7 (59.5, 78.0) | 67.1 (59.4, 74.8) | 65.9 (55.4, 76.3) | 70.7 (60.2, 81.1) | 67.2 (54.9, 79.6) | 67.3 (53.9, 80.8) |
| IRSAD quintile, % (95% CI) | | | | | | |
| 1 (Most disadvantaged) | 16.2 (8.8, 23.5) | 17.8 (11.5, 24.0) | 19.6 (10.9, 28.4) | 20.0 (10.8, 29.2) | 22.4 (11.5, 33.4) | 20.4 (8.9, 31.9) |
| 2 | 23.2 (14.8, 31.7) | 15.1 (9.2, 20.1) | 13.5 (6.0, 21.1) | 22.7 (13.1, 32.3) | 15.5 (6.0, 25.0) | 16.3 (5.7, 26.9) |
| 3 | 14.1 (7.2, 21.1) | 21.2 (4.5, 27.9) | 18.7 (10.0, 27.3) | 16.0 (7.6, 24.4) | 13.8 (4.7, 22.9) | 34.7 (21.1, 48.3) |
| 4 | 25.3 (16.7, 33.9) | 24.7 (17.6, 31.7) | 28.3 (18.3, 38.2) | 20.0 (10.8, 29.2) | 31.0 (18.9, 43.2) | 14.3 (4.3, 24.3) |
| 5 (Least disadvantaged) | 21.2 (13.1, 29.3) | 21.2 (14.5, 27.9) | 19.9 (11.0, 28.7) | 21.3 (11.9, 30.7) | 17.2 (7.3, 27.2) | 14.3 (4.3, 24.3) |
| ARIA classification, % (95% CI) | | | | | | |
| Major city | 51.1 (41.6, 61.5) | 55.6 (47.5, 64.0) | 63.7 (53.0, 74.3) | 50.7 (39.2, 62.1) | 51.7 (38.6, 64.8) | 49.0 (34.7, 63.3) |
| Inner regional | 33.3 (24.0, 42.7) | 29.7 (22.1, 37.2) | 20.1 (11.2, 29.0) | 30.7 (20.1, 41.3) | 24.1 (12.9, 35.4) | 30.6 (17.4, 43.8) |
| Outer regional/remote | 15.2 (8.0, 22.3) | 14.6 (8.7, 20.4) | 16.2 (8.0, 24.4) | 18.7 (9.8, 27.6) | 24.1 (12.9, 35.4) | 20.4 (8.9, 31.9) |
| Burn cause, % (95% CI) | | | | | | |
| Flame | 43.4 (33.6, 53.3) | 48.6 (40.5, 56.8) | 43.9 (33.0, 54.8) | 58.7 (47.4, 70.0) | 43.1 (30.1, 56.1) | 55.1 (40.9, 69.3) |
| Scald | 33.3 (24.0, 42.7) | 27.4 (20.1, 34.7) | 30.5 (20.4, 40.6) | 20.0 (10.8, 29.2) | 29.3 (17.4, 41.3) | 14.3 (4.3, 24.3) |
| Contact | 17.2 (9.7, 24.7) | 11.6 (6.4, 16.9) | 15.9 (7.8, 23.9) | 10.7 (3.6, 17.8) | 15.5 (6.0, 25.0) | 18.4 (7.3, 29.5) |
| Other | 6.1 (1.3, 10.8) | 12.3 (7.0, 17.7) | 9.8 (3.2, 16.3) | 10.7 (3.6, 17.8) | 12.1 (3.5, 20.6) | 12.2 (2.9, 21.6) |
| %TBSA, % (95% CI) | | | | | | |
| Mean %TBSA | 8.5 (6.2, 10.8) | 8.8 (7.3, 10.4) | 8.7 (6.6, 10.9) | 13.3 (9.6, 17.0) | 8.6 (5.6, 11.6) | 14.2 (9.2, 19.1) |
| < 10% TBSA | 73.2 (64.3, 82.2) | 65.1 (57.3, 72.9) | 67.0 (56.6, 77.3) | 56.0 (44.6, 67.4) | 70.3 (58.3, 82.4) | 51.0 (36.7, 65.3) |
| 10–19% TBSA | 12.6 (5.9, 19.4) | 19.9 (13.3, 26.4) | 19.6 (10.9, 28.4) | 21.3 (11.9, 30.7) | 17.6 (7.5, 27.7) | 26.5 (13.9, 39.2) |
| ≥ 20% TBSA | 14.1 (7.2, 21.1) | 15.1 (9.2, 20.9) | 13.4 (5.9, 20.9) | 22.7 (13.1, 32.3) | 12.1 (3.5, 20.6) | 22.4 (10.5, 36.4) |
| Burn depth, % (95% CI) | | | | | | |
| Superficial | 17.1 (8.7, 25.5) | 16.0 (9.7, 22.4) | 20.0 (9.7, 30.3) | 10.7 (2.6, 18.7) | 24.5 (10.7, 38.2) | 8.6 (0.0, 17.5) |
| Mid-dermal | 30.9 (20.7, 41.1) | 31.7 (22.5, 40.9) | 32.7 (21.6, 43.8) | 33.7 (19.9, 47.6) | 30.2 (16.1, 44.3) | 30.8 (14.7, 47.0) |
| Deep/Full thickness | 52.0 (41.1, 62.9) | 52.3 (43.0, 61.5) | 47.3 (34.9, 59.8) | 55.6 (40.6, 70.6) | 45.3 (30.2, 60.5) | 60.6 (43.2, 78.0) |
| Inhalation injury, % (95% CI) | | | | | | |
| No | 97.0 (93.6, 100) | 94.5 (90.8, 98.2) | 93.9 (88.7, 99.2) | 92.0 (85.8, 98.2) | 94.8 (89.0, 100) | 93.9 (87.0, 100) |
| Yes | 3.0 (0.0, 6.4) | 5.5 (1.8, 9.2) | 6.1 (0.8, 11.3) | 8.0 (1.8, 14.2) | 5.2 (0, 11.0) | 6.1 (0, 13.0) |
| Theatre for management, % (95% CI) | | | | | | |
| No | 17.2 (9.7, 24.7) | 17.0 (10.7, 23.2) | 9.8 (3.2, 16.3) | 12.8 (5.0, 20.6) | 15.5 (6.0, 25.0) | 8.2 (0.3, 16.0) |
| Yes | 82.8 (75.3, 90.3) | 83.0 (76.8, 89.3) | 90.2 (83.7, 96.8) | 87.2 (79.4, 95.0) | 84.5 (75.0, 94.0) | 91.8 (84.0, 99.7) |
| Skin graft, % (95% CI) | | | | | | |
| No | 41.4 (31.6, 51.2) | 32.5 (24.7, 40.2) | 30.5 (20.4, 40.6) | 28.8 (18.3, 39.3) | 36.2 (23.6, 48.8) | 16.3 (5.7, 26.9) |
| Yes | 58.6 (48.8, 68.4) | 67.5 (59.8, 75.3) | 69.5 (59.4, 79.6) | 71.2 (60.7, 81.7) | 63.8 (51.2, 76.4) | 83.7 (73.1, 94.3) |

*ARIA* Accessibility/Remoteness Index of Australia, *CI* confidence interval, *IRSAD* Index of Relative Socio-Economic Advantage and Disadvantage, *TBSA* total body surface area.

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**Table 2.** Predictors of reporting itch at follow-up (multivariable model)

| Predictor | Adjusted odds ratio (95% CI) | *P* value |
|---|---|---|
| Time since injury | | |
| 1-month (reference) | 1.00 | 0.006 |
| 6-months | 0.48 (0.28, 0.82) | |
| 12-months | 0.42 (0.22, 0.78) | |
| Age, years | | |
| 18–34 (reference) | 1.00 | 0.03 |
| 35–49 | 0.41 (0.20, 0.82) | |
| ≥ 50 | 0.45 (0.22, 0.91) | |
| %TBSA | | |
| < 10% (reference) | 1.00 | 0.22 |
| 10–19% | 1.99 (0.91, 4.34) | |
| ≥ 20% | 1.30 (0.52, 3.25) | |
| Cause | | |
| Flame (reference) | 1.00 | 0.08 |
| Scald | 0.48 (0.24, 0.98) | |
| Contact | 0.47 (0.19, 1.13) | |
| Other | 1.07(0.40, 2.83) | |

*CI* confidence interval, *TBSA* total body surface area

Time since injury and patient age were important independent predictors of reporting itch (Table 2). The adjusted odds of reporting itch at 6 and 12 months post-injury were 52% and 58% lower when compared to 1 month post-injury, respectively (Table 2). Compared to patients aged 18–34 years, the adjusted odds of reporting itch were 59% lower for patients aged 35–49 years and 55% lower for patients over the age of 50 (Table 3).

### Predictors of moderate to severe pain at follow-up

The characteristics of patients with and without moderate to severe pain at 1, 6, and 12 months are presented in Table 3. Table S3 shows the complete output for the univariable testing of predictors and experiencing moderate to severe pain. Time since injury ($p = 0.009$), patient age ($p = 0.023$), %TBSA ($p = 0.16$), whether the patient had their burn grafted ($p = 0.01$), burn depth ($p = 0.058$), and the presence of an inhalation injury ($p = 0.15$) were associated with the prevalence of moderate to severe pain in univariable testing and were subsequently entered into the multivariable model (Table 5).

Time since injury and age were important independent predictors of reporting moderate to severe pain at follow-up (Table 4). The adjusted odds of reporting moderate to severe pain at 6 and 12 months post-injury were 48% and 64%, respectively, lower when compared to 1 month post-injury (Table 4). The adjusted odds of reporting moderate to severe pain were 3.12- and 3.42-fold higher for patients aged 35–49 years and patients aged ≥50 years, respectively, compared to patients aged 18–34 years (Table 4).

## Discussion

This study involved 328 patients hospitalized to one of five specialist burns units that were followed for 12 months post-burn. Typically, patients managed in Australian burn centers have access to specialist dressing systems, high-acuity critical care, early skin closure surgery, and acute pain services within the first few weeks of admission. Itch was a commonly reported symptom following burn injury, but pain interfered more than itch on physical and mental health, particularly with respect to social, physical, and emotional functioning. At 12 months post-burn, 27% of patients continued to experience some level of itch (a decrease from 50% at 1 month post-injury), while just 13% of patients continued to experience moderate to severe pain (a reduction from 23% at 1 month post-injury). Patients who reported experiencing itch at follow-up experienced poorer physical and mental health compared to patients who did not experience itch. Patients who reported moderate to severe pain at follow-up experienced significantly poorer mental and physical health, and greater work-related disability. The adjusted odds of experiencing itch decreased with time since follow-up and with age. The adjusted odds of experiencing moderate to severe pain decreased with time since follow-up but increased with age.

The prevalence of any itch following burn injury was consistent with previous estimates of 50% [4] at the 1-month follow-up. The prevalence of any itch following burn injury decreased as follow-up progressed. This trend is in line with previous reports from Demling and DeSanti, where itch decreases as the scars mature and resolve [38]. However, the reported prevalence of itch during the follow-up period is also lower than the 83% of patients with pruritus at 12-months as reported by Carrougher et al. [16]. The discrepancy between the findings of this study and that of Carrougher et al. may be explained by differences in the two study populations with respect to the median burn size. Carrougher et al. recruited patients from the US National Institute of Disability and Rehabilitation Research Burn Model System, which has more severe inclusion criteria [17] compared to the criteria used in the current study [39]. As measures of burn severity have previously been identified as predictors of itch [6, 14], it is understandable why a cohort of more severely burned patients reports a higher proportion of patients experiencing itch compared to a cohort of patients with less-severe burn injuries.

The prevalence of moderate to severe pain following burn injury ranged between 13% and 23% at follow-up. This is similar to the 18% of patients who reported persistent burn-related pain up to 11 years post-injury in an earlier Western Australian study [11], but lower than the 35% and 52% of patients reporting pain in two Canadian studies [8, 9] and one American study [10], respectively. Variations in the prevalence of pain following burn injury may arise through many factors. These include variations due to the categorization of pain (i.e., moderate to severe versus any pain), the tool used to measure

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**Table 3.** Profile of participants by pain group at each time point post-injury

| Characteristic | 1-month | | 6-months | | 12-months | |
|---|---|---|---|---|---|---|
| | No/mild pain (n = 225) | Moderate/severe pain (n = 66) | No/mild pain (n = 182) | Moderate/severe pain (n = 36) | No/mild pain (n = 160) | Moderate/severe pain (n = 23) |
| Age, mean (95% CI), years | 41.9 (39.7, 44.2) | 43.0 (39.4, 46.6) | 42.8 (40.4, 45.1) | 50.3 (45.1, 55.5) | 43.7 (41.0, 46.3) | 54.8 (49.2, 60.4) |
| Gender, % (95% CI) | | | | | | |
| Female | 29.3 (23.3, 35.3) | 42.4 (30.4, 54.5) | 31.3 (24.5, 38.1) | 30.6 (15.2, 45.9) | 30.6 (23.4, 37.8) | 39.1 (18.6, 59.7) |
| Male | 70.7 (64.7, 76.7) | 57.6 (45.5, 69.6) | 68.7 (61.9, 75.5) | 69.4 (54.1, 84.8) | 69.4 (62.2, 76.6) | 60.9 (40.3, 81.4) |
| IRSAD quintile, % (95% CI) | | | | | | |
| 1 (Most disadvantaged) | 16.5 (11.6, 21.4) | 19.7 (10.0, 29.4) | 16.0 (10.6, 21.4) | 30.6 (15.2, 45.9) | 18.2 (12.1, 24.2) | 17.4 (1.4, 33.3) |
| 2 | 17.9 (12.8, 22.9) | 18.2 (8.8, 27.6) | 18.8 (13.0, 24.5) | 13.9 (2.4, 25.4) | 16.3 (10.5, 22.2) | 21.7 (4.4, 39.1) |
| 3 | 18.3 (13.2, 23.4) | 18.2 (8.8, 27.6) | 17.2 (11.6, 22.8) | 8.3 (0.0, 17.5) | 22.1 (15.5, 28.6) | 17.4 (1.4, 33.3) |
| 4 | 23.7 (18.1, 29.3) | 27.3 (16.4, 38.1) | 23.7 (17.5, 30.0) | 33.3 (17.7, 49.0) | 22.6 (16.1, 29.2) | 34.8 (14.7, 54.8) |
| 5 (Least disadvantaged) | 23.6 (18.0, 29.2) | 16.7 (7.8, 25.8) | 24.3 (18.0, 30.7) | 13.9 (2.4, 25.4) | 20.8 (14.4, 27.2) | 8.7 (0.0, 20.5) |
| ARIA classification, % (95% CI) | | | | | | |
| Major city | 52.8 (46.2, 59.5) | 57.6 (45.5, 69.6) | 60.5 (53.4, 67.7) | 58.3 (41.9, 74.8) | 54.5 (46.7, 62.3) | 47.8 (26.8, 68.8) |
| Inner regional | 31.8 (25.6, 38.0) | 30.3 (19.1, 41.5) | 24.5 (18.1, 30.8) | 25.0 (10.6, 39.4) | 26.5 (19.6, 33.5) | 34.8 (14.8, 54.8) |
| Outer regional/remote | 15.3 (10.5, 20.1) | 12.1 (4.2, 20.1) | 15.0 (9.7, 20.3) | 16.7 (4.3, 29.1) | 19.0 (12.8, 25.3) | 17.4 (1.4, 33.3) |
| Burn cause, % (95% CI) | | | | | | |
| Flame | 44.0 (37.5, 50.5) | 53.0 (40.8, 65.2) | 47.3 (39.9, 54.6) | 58.3 (41.9, 74.8) | 46.3 (38.4, 54.1) | 56.5 (35.7, 77.4) |
| Scald | 28.0 (22.1, 33.9) | 30.3 (19.1, 41.5) | 28.0 (21.4, 34.6) | 19.4 (6.3, 32.6) | 24.4 (17.7, 31.1) | 21.7 (4.4, 39.1) |
| Contact | 18.7 (13.5, 23.8) | 7.6 (1.1, 14.0) | 13.2 (8.2, 18.1) | 13.9 (2.4, 25.4) | 16.3 (10.5, 22.0) | 13.0 (0.0, 27.2) |
| Other | 9.3 (5.5, 13.2) | 9.1 (2.1, 16.1) | 11.5 (6.9, 16.2) | 8.3 (0.0, 17.5) | 13.1 (7.8, 18.4) | 8.7 (0.0, 20.5) |
| % TBSA, % (95% CI) | | | | | | |
| Mean %TBSA | 7.4 (6.3, 8.6) | 10.0 (7.6, 12.3) | 9.0 (7.3, 10.7) | 14.4 (8.9, 19.9) | 10.1 (8.0, 12.1) | 7.1 (4.2, 9.9) |
| < 10% TBSA | 73.1 (67.2, 79.0) | 59.1 (47.1, 71.1) | 69.1 (62.3, 75.9) | 55.6 (39.0, 72.1) | 64.2 (56.7, 71.8) | 78.3 (60.9, 95.6) |
| 10–19% TBSA | 15.8 (10.9, 20.6) | 22.7 (12.5, 33.0) | 18.2 (12.6, 23.9) | 16.7 (4.3, 29.1) | 20.8 (14.4, 27.1) | 17.4 (1.4, 33.3) |
| ≥ 20% TBSA | 11.1 (7.0, 15.2) | 18.2 (8.8, 27.6) | 12.6 (7.8, 17.5) | 27.7 (12.9, 42.7) | 15.0 (9.4, 20.6) | 4.3 (0.0, 12.9) |
| Burn depth, % (95% CI) | | | | | | |
| Superficial | 19.4 (13.5, 25.3) | 10.0 (2.1, 17.9) | 19.0 (12.9, 25.1) | 11.1 (0.0, 23.3) | 16.5 (10.2, 22.8) | 21.3 (2.8, 39.8) |
| Mid-dermal | 30.6 (23.8, 37.4) | 26.5 (14.3, 38.7) | 32.4 (24.4, 40.3) | 21.7 (3.4, 39.9) | 33.9 (25.2, 42.7) | 30.9 (9.4, 52.3) |
| Deep/Full thickness | 50.0 (43.1, 56.9) | 63.5 (50.0, 76.9) | 48.6 (40.4, 57.0) | 67.2 (48.2, 86.2) | 49.6 (40.6, 58.5) | 47.8 (25.1, 70.5) |
| Inhalation injury, % (95% CI) | | | | | | |
| No | 96.4 (94.0, 98.9) | 93.9 (88.1, 99.8) | 95.1 (91.9, 98.2) | 88.9 (78.4, 99.4) | 95.6 (92.4, 98.8) | 95.7 (87.1, 100) |
| Yes | 3.6 (1.1, 6.0) | 6.1 (0.2, 11.9) | 4.9 (1.8, 8.1) | 11.1 (0.6, 21.6) | 4.4 (1.2, 7.6) | 4.3 (0.0, 12.9) |
| Theatre for management, % (95% CI) | | | | | | |
| No | 19.3 (14.1, 24.6) | 12.1 (4.2, 20.1) | 14.6 (9.4, 19.8) | 8.3 (0.0, 17.5) | 11.9 (6.9, 16.9) | 8.7 (0.0, 20.5) |
| Yes | 80.7 (75.4, 85.9) | 87.9 (79.9, 95.8) | 85.4 (80.2, 90.6) | 91.7 (82.5, 100) | 88.1 (83.1, 93.2) | 91.3 (79.5, 100) |
| Skin graft, % (95% CI) | | | | | | |
| No | 40.1 (33.6, 46.7) | 27.3 (16.4, 38.1) | 37.4 (30.2, 44.5) | 22.2 (8.4, 36.1) | 33.1 (25.8, 40.5) | 39.1 (18.6, 59.7) |
| Yes | 59.9 (53.3, 66.4) | 72.7 (61.9, 83.6) | 62.6 (55.5, 69.8) | 77.8 (63.9, 91.6) | 66.9 (59.5, 74.2) | 60.9 (40.3, 81.4) |

*ARIA* Accessibility/Remoteness Index of Australia, *CI* confidence interval, *IRSAD* Index of Relative Socio-Economic Advantage and Disadvantage, *TBSA* total body surface area.

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**Table 4.** Predictors of reporting moderate to severe pain at follow-up (multivariable model)

| Predictor | Adjusted odds ratio (95% CI) | *P* value |
|---|---|---|
| Time since injury | | |
| 1-month (reference) | 1.00 | 0.004 |
| 6-months | 0.52 (0.29, 0.91) | |
| 12-months | 0.36 (0.19, 0.69) | |
| Age, years | | |
| 18–34 (reference) | 1.00 | 0.009 |
| 35–49 | 3.12 (1.35, 7.20) | |
| ≥ 50 | 3.42 (1.47, 7.93) | |
| % TBSA | | |
| < 10% TBSA (reference) | 1.00 | 0.27 |
| 10–19% TBSA | 1.42 (0.61, 3.31) | |
| ≥ 20% TBSA | 2.43 (0.80, 7.33) | |
| Skin graft | | |
| No (reference) | 1.00 | 0.15 |
| Yes | 1.80 (0.80, 4.01) | |
| Burn Depth | | |
| Superficial (reference) | 1.00 | 0.24 |
| Mid-dermal ± superficial | 0.89 (0.27, 3.00) | |
| Deep/FT ± superficial/mid | 1.88 (0.57, 6.28) | |
| Inhalation injury | | |
| No (reference) | 1.00 | 0.25 |
| Yes | 1.21 (0.27, 5.38) | |

*CI* confidence interval, *FT* full thickness, *TBSA* total body surface area

pain (the SF-36 V2 versus yes/no questions, the McGill Pain Questionnaire, and the Brief Pain Inventory), and differences in the duration of patient follow-up since injury (1, 6, and 12 months versus up to 12 years post-injury).

The finding that 91% of patients had returned to work at the 12-month follow-up time point exceeds the mean return to work rate of 66% reported by a systematic review of factors influencing return to work in a burns population [40]. The proportion of patients who were able to return to work at 12 months also exceeds the 84% of orthopedic or other major trauma patients who had successfully returned to work at 12 months post-injury [41]. Reporting itch after burn injury did not influence the proportion of patients that had successfully returned to work at any of the follow-up time points. This is consistent with itch not being identified as a factor affecting return to work following burn injury [40]. Fewer patients reporting moderate to severe pain after burn injury had returned to work at each follow-up time point compared to patients without pain. Pain accounts for a significant proportion of work absences [42–44], and numerous barriers to return to work have been identified for individuals living with chronic pain [45]. The proportion of patients reporting moderate to severe pain who had returned to work in this study—ranging from 22% at 1 month to 63% at 12 months—is well below reported estimates of 68% at 1 month to 93% at follow-ups beyond 6 months in patients with musculoskeletal low back pain [46].

Itch interfered with life to a greater extent during the early stages following burn injury, and patients who reported experiencing itch also reported lower health-related quality of life as measured by the SF-36 V2 compared to itch-free patients. This finding is consistent with previous reports of itch having serious impact on the well-being and functioning of burns patients [6, 16]. The finding that burns patients reporting moderate to severe pain also reported lower health-related quality of life at each of the follow-up time points is consistent with previous research reporting lower health-related quality of life in patients with chronic pain compared to pain-free populations [47–50]. In this study, it appears that pain has greater impact on long-term health-related quality of life compared to itch following a burn injury.

Our observed finding of decreased odds of reporting itch at 12 months compared to 1 month is consistent with that of Demling and DeSanti [38], who report that itch following a burn injury usually peaks between 2 and 6 months post-injury and resolves with scar maturation between 12-and 18 months post-injury. Our observed finding that the odds of reporting itch decrease with age is consistent with that of a recent large-scale study investigating risk factors associated with itch from Carrougher et al. [16], who report that the *intensity* of itch decreases with age. The finding that the odds of experiencing itch decreasing with age may be explained by a reduced concentration of mast cells [51], as the increased release of histamine from mast cells during wound healing contributes to the sensation of itch [52, 53]. However, it is important to remember that previous studies [6, 12, 16] investigating predictors of itch following burn injury measured itch primarily through intensity (as opposed to a global measures of itch interference), meaning that direct comparisons with the current study may be somewhat difficult.

Many previous studies examining pain after burn injury have been cross-sectional—only collecting data at one time point—rather than undertaking ongoing follow-ups with patients over time [8–11]. Other studies such as Corry et al. [54], who followed-up 171 American burns patients at 1, 6, 12, and 24 months post-discharge and collected pain-related measures, did not analyze their pain-related data as an outcome of interest. Our observed finding of decreased odds of reporting moderate to severe pain over time is inconsistent with that of Edwards et al. [55], who reported that time since burn injury was not a significant predictor of bodily pain in their follow-up study of 526 patients over a two-year period. However, it is important to note that both Ullrich et al. [56] and Edwards et al. [55] reported decreases in mean bodily pain as time since injury increased (i.e., to a two-year follow-up), suggesting that there may be some merit to our observation. The finding that 13% of patients experienced moderate to severe pain at 12 months post-burn is lower than the 26% reported by Giummarra et al. at the same time-point in a more generalized trauma population [57].

The observed finding of greater odds of moderate to severe pain with increasing age is consistent with previous reports. Blyth et al. [58] interviewed 17,543 individuals to determine the prevalence of chronic pain in Australia and reported that

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older age, along with other factors such as female gender, was an important risk factor for chronic pain. Edwards et al. [55] also found that older age was strongly associated with bodily pain as reported via the SF-36 V2. The finding of greater odds of experiencing pain with increasing age may be explained by age-related changes in the structure and function of the nociceptive system [59–61].

The %TBSA burned and whether the patient received a skin graft were not found to be significant predictors of itch in the current study, contrary to previous reports [6, 12, 14–16, 62, 63]. Differences in statistical analysis exist between this study and previously published studies. Previous studies used linear regression to identify predictors of itch as a continuous measure [6, 16, 62], whereas this study used logistic regression to investigate itch as a dichotomous measure. Previous studies also included %TBSA as an untransformed continuous [6, 16, 62, 63], log-transformed [15], or abnormally categorized measure [14] measure as a predictor in their regression analyses. Differences also exist in the question or questionnaire used to classify and quantify itch. Kwa et al. [62] used the Burns Itch Questionnaire [64], Gauffin et al. used the Questionnaire for Pruritus Assessment [15], Willebrand et al. used a single question from the Abbreviated Burns Specific Health Scale [63], while Caesar et al. [14] asked patients to rate their itch as none, moderate, or severe. Together, these factors may explain why this study did not identify %TBSA or grafting and surgical procedures as predictors of itch following burn injury.

A detailed discussion of the strengths and weaknesses of this study are described elsewhere [20]. A key strength of this study was its multicenter approach and longitudinal design in a cohort of burns patients that was representative of the broader burn injury population in Australia and New Zealand. The major limitation relevant to this study is that a specially designed itch-related questionnaire was used due to the absence of an existing validated measure at the time of the study. Since the development of this study, validation studies of multiple itch questionnaires have been published [64, 65]. Using a validated questionnaire relating to itch severity in a study such as this may have yielded different results. This important limitation needs to be considered when attempting to interpret the findings of this study to other research using a validated itch questionnaire.

## Conclusions

Itch was a more commonly reported symptom than pain in the first 12 months following a burn injury. However, pain was associated with significantly poorer mental and physical health and greater work-related disability compared to itch. Pain was also a more substantial barrier for successful return to work, and was associated with greater work-related disability, compared to itch. Time since injury was an important predictor of both itch and pain. Additional research is required to enhance our understanding of potentially modifiable factors (e.g., surgery) that influence pain and itch, which may lessen the overall burden of burn injuries. Interesting future studies may also include investigation of the impact of dressing systems, acute and post-discharge medication regimes, post-discharge lotion and scar treatment regimes, and adherence to physical interventions (e.g., massage).

## Abbreviations

ANZBA: Australian and New Zealand Burns Association; ARIA: Accessibility/Remoteness Index of Australia; Bi-NBR: Bi-National Burns Registry; BRANZ: Burns Registry of Australia and New Zealand; CI: confidence interval; FT: full thickness; HREC: Human Research Ethics Committee; ICU: intensive care unit; IRSAD: Index of Relative Socio-Economic Advantage and Disadvantage; IQR: interquartile range; LOS: length of stay; LTO: long-term outcomes; MAR: missing at random; MICE: multiple imputation by chained equations; OR: odds ratio; SD: standard deviation; SF-36 V2: Short Form Health Survey Version 2; SIP: Sickness Impact Profile; %TBSA: percentage total body surface area.

## Supplementary material

Supplementary material is available at *BURNST Journal* online.

## Declarations

Not applicable.

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## Availability of data and materials

The data sets generated and analyzed during the current study are not publicly available, as the authors do not have permission to share these data publicly.

## Authors' contributions

BJG, HC, DWE, and RS were involved in the conceptualization of the study, the development of the methodology, and overseeing of data collection. BJG was responsible for data curation. LMT analyzed the data while HC and BJG advised on data analysis. LMT wrote the initial draft of the manuscript, while all authors contributed to the review and editing of the manuscript. All authors read and approved the final version of the manuscript.

## Ethics approval

This project received Human Research Ethics Committee (HREC) approval from Monash University as well as the five participating sites. Participants at four of the sites (The Alfred, the Royal Adelaide Hospital, the Concord Repatriation General Hospital, and the Royal Hobart Hospital) provided written informed consent prior to entering the study. Participants at the Royal Perth Hospital did not provide written informed consent due to an existing waiver of consent from the appropriate HREC allowing them to follow all survivors to discharge from hospital.

## Consent for publication

Not applicable.

## Conflicts of interest

The authors declare that they have no competing interests.

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