

1 MAIN TEXT

2 Introduction

3 Antarctica remains one of the world's great wildernesses¹. Australia maintains three year
4 round permanent Antarctic stations (Mawson, Davis and Casey) and one subantarctic station
5 on Macquarie Island. The Tasmanian based Australian Antarctic Division (AAD) manages
6 these stations in the Australian Antarctic Territory (AAT) and the subantarctic.

7 Expeditioners who work and live in these remote and isolated environments must be self-
8 sufficient to provide immediate responses to a range of potential emergencies. History of
9 human expeditions have included accidents, injuries and fatalities, and these events have
10 occurred during Australia's scientific efforts in Antarctica. A review of medical presentations
11 of Australian Antarctic expeditioners between 1988—1997, showed 3,910 cases of injury or
12 poisoning accounted for 42% of all medical presentations². Morbidity reviews by other
13 nations reveal similar figures from Indian³, Japanese⁴ and British⁵ Antarctic stations.

14 Medical emergencies are relatively common in extreme and remote locations and often differ
15 in type from those of general populations. For example, injuries or acute musculoskeletal
16 problems occur at higher rates than comparative presentations in Australia⁶ and most likely to
17 require emergency first aid. Despite the significant risks to expeditioners' morbidity and
18 mortality, there is currently no publically available data on expeditioners' levels of first aid
19 training or their abilities to apply that training in times of need or potential to improve skills
20 and self-efficacy to carry out first aid actions^{7,8,9,10,11}. New advances in training have proven
21 benefits, particularly in casualty care at the point of injury with improved survival rates¹².

22 ~~Australian~~ AAD employed expeditioners undergo a variety of training courses prior to
23 departure and are required to have a basic first aid and cardiopulmonary resuscitation
24 certificate at the time of ~~AAD~~-employment. Most do not receive additional first aid training

25 before departure. Wintering teams undertake search and rescue training and an intensive
26 firefighting course, to provide an emergency response team. All expeditioners are provided
27 with a copy of the Australian Antarctic First Aid Manual¹³ and are expected to be familiar
28 with the contents and have access to this at all times. Additional first aid training may be
29 required for those involved in higher risk activities or deep field parties. The wilderness first
30 aid guidelines produced by Johnson et al.¹⁴ state that first aid courses should focus on non-
31 medical persons who do not provide medical care¹⁵. This is commensurate with the
32 requirements of Australian Antarctic expeditioners who may be called upon to provide
33 emergency first aid (either on station, on ships or in the field) in addition to their normal
34 duties. The lack of external emergency response support in Antarctica adds weight to the
35 argument that proficiency in appropriate remote and austere environment first aid is highly
36 desirable for extreme condition personnel.

37 This study was developed as a first-ever assessment of first aid response readiness of both
38 summer and winter Australian Antarctic Program (AAP) expeditioners. To test current
39 preparedness, we examined expeditioners' first aid qualifications and perceived ability to
40 apply first aid to a variety of real-world medical emergencies in extreme conditions.

41 **Methods**

42 **Study Design**

43 A mixed method approach was employed, through an anonymous survey, with good validity
44 for capturing potentially sensitive information¹⁶. A questionnaire included items assessing
45 expeditioners' demographics, first aid qualifications, emergency first aid self-efficacy, and
46 opinions regarding first aid training. A copy of the questionnaire is available in Appendix 1
47 Study inclusion criteria were: personnel working at one of Australia's three continental
48 Antarctic stations, and active during the 2016/17 summer and/or 2017 winter seasons.

49 Invitation emails were sent to 196 expeditioners (wintering and summer), including a link to
50 the survey, which was open from January to April 2017. No other data were available for the
51 study population. Ethics clearance was granted by the Tasmania Health and Medical Human
52 Research Ethics Committee at the University of Tasmania, Australia (Ethics no.H0016078).

53 **Measure**

54 The questionnaire, including the EC-FACS, were developed using published research on
55 perceptions of self-confidence in providing emergency first aid¹⁷ and the scenarios were
56 primarily based on the lead author's 33 years of experience as a physician and two
57 expeditions to an Australian Antarctic research station as the sole medical officer. The
58 questionnaire consisted of 19 items arranged by themed groups.

59 *Antarctic Experience.* Three questions asked expeditioners about prior Antarctic work
60 experience and numbers of previous trips.

61 *First Aid Qualifications and Experience.* Three questions assessed current or prior health
62 professional qualifications, participants' highest level of first aid training, and time since that
63 training. Two questions asked about previous experiences in providing emergency first aid.

64 *Extreme Conditions First Aid Confidence Scale (EC –FACS).* Nine questions assessed
65 participants' self-efficacy regarding readiness to respond to a range of first aid scenarios, as
66 well as their overall confidence to provide first-aid in Antarctica. The scenarios were
67 presented in order of escalating medical severity and urgency. The first aid scenarios ranged
68 from minor events to serious life-threatening events. They were selected to represent the
69 range of illness and injury that could occur in their everyday workplace, those that are
70 associated with higher risk outdoor activities, and those that were more likely to be
71 encountered in a polar environment.

72 The eight first aid scenarios are described in **the Question 10 of Appendix 1** and include;
73 minor illness, minor fracture, major fracture, unconscious with head injury, spinal injury,
74 multiple severe injuries, mild hypothermia and severe hypothermia. Responses were scored
75 on a five-point response set 1 = “not at all confident” to 5 = “highly confident”¹⁸.
76 Expeditioners were also asked “*Overall, how confident do you feel to provide emergency first*
77 *aid in Antarctica?*” Eight items were combined to form the EC-FACS (range = 8 – 40), with
78 higher scores indicating greater self-efficacy in providing extreme condition first aid.

79 **Analysis**

80 The data were cleansed **by identifying and treating multivariate outliers and missing values,**
81 **following procedures of Tabachnick and Fidell¹⁹** and missing values analyses determined
82 (0.0–8.4% missing). Data missing completely at random (MCAR) were replaced through the
83 expectation maximisation algorithm. Descriptive statistics assessed demographic and primary
84 results. Chi-square tests examined associations between categorical variables. Associations
85 between self-efficacy and other variables were explored with Pearson and point-biserial
86 correlations, followed with hierarchical regression modelling to predict overall self-efficacy.
87 Analyses used R v.3.4.0²⁰ and SPSS v.22 (IBM Corp.). Open-ended responses were
88 examined using thematic analysis as described by Braun and Clarke²¹ and Hsieh and
89 Shannon²². Using direct content analysis, individual ideas were identified and assigned
90 numerical codes for descriptive statistics. The expeditioners’ topics were grouped on
91 common themes.

92 **Results**

93 **Participants**

94 Among the 196 expeditioners, 131 (66.8%) were in Antarctica for summer or winter and 65
95 (33.2%) were present for both seasons; 91 accessed the survey link and 83 completed the

96 questionnaire, for a 42.3% response rate. Chi-squares revealed more year-long expeditioners
97 (60.0%) responded to the questionnaire than short-season expeditioners (32.1%), $X^2 = 5.49$, p
98 $= 0.02$. There were no additional demographic data available on non-respondents.

99 Table 1 presents characteristics of the 83 participants. There were 65 (78%) males and 18
100 (22%) females. Ages ranged from 24—72 years ($M = 43.5$, $SD = 11.6$). Most expeditioners
101 were Australian, five from New Zealand, and one each from Canada, South Africa, Sweden,
102 UK and USA. Participants reported 0—16 previous Antarctic trips, with 30.1% on their first
103 expedition, 56.6% on their second to sixth expedition, and 13.3% on their seventh to
104 sixteenth expedition.

105 **First Aid Qualifications**

106 Men were more likely than women to report previous Antarctic experience (43% versus 16%,
107 $p = .02$), while women were more likely to hold tertiary qualifications (89% versus 49%, $p =$
108 $.003$). Other comparisons on sex were not statistically significant or violated test
109 assumptions. Chi-square analyses showed no significant differences comparing first aid
110 qualifications on age, length of Antarctic season or education ($p > .05$).

111 Sixty-three percent attained a first aid qualification within three years of commencing their
112 expedition. Conversely, 37.0% had exceeded the three-year threshold for repeat training
113 recommended by Safe Work Australia²³. Table 2 shows participants' medical qualifications
114 and first aid qualification levels and experience. Only 7.2% had a professional health
115 qualification, while only 3.6% lacked any first aid training. About a third (33.7%) held the
116 highest first aid training level, wilderness first aid. Almost half (44.6%) of participants
117 obtained first aid training within one year of starting their expedition, while 20.5% obtained
118 their training more than four years prior. Half of participants had no experience delivering
119 emergency first aid, but over a quarter did so three times or more. Analyses revealed 60.0%

120 had only basic first aid qualifications, while three returning expeditioners had no first aid
121 qualifications.

122 **Confidence to provide extreme conditions first aid**

123 Table 3 presents response patterns for first aid scenarios and overall confidence. For all
124 situations, except minor injury, all scenario response options received at least one
125 endorsement. The minor injury item showed a ceiling effect, as most participants (89.1%)
126 expressed high or very high confidence in handling minor illnesses in extreme conditions,
127 therefore, that item was removed from further analyses. The remaining eight items were
128 subjected to exploratory factor analysis (principal axis factoring, direct oblimin rotation). The
129 scree plot and parallel analysis showed a single factor solution fit the data best, which
130 explained 68.9% of variance in the underlying factor. Communalities and factor loadings
131 were all moderate to high (extracted $h^2 = .42—.83$; factor loadings = $.64—.91$). Therefore,
132 these items were combined and assessed on a single scale for later analyses — the ECFACS.
133 The eight items demonstrated strong internal consistency, inter-item $r = .41—.86$; and item-
134 total, $r = .63—.88$; and $\alpha = .94$.

135 **Predicting medical emergency self-efficacy**

136 Pearson and point-biserial correlations showed a strong positive correlation between the
137 number of times first aid had been provided and Overall Confidence, $r = .59$, $p < .001$. Age
138 and male sex showed consistent positive associations with all scenario items and EC-FACS
139 scores, while education showed no strong relationship with first aid self-efficacy. Previous
140 work in Antarctica, number of previous trips, and time since first aid qualification were only
141 weakly related to scenario items and total scores. First aid qualification level and experience
142 providing first aid, however, showed consistently strong positive associations with scenario
143 items and EC-FACS scores.

144 Hierarchical linear regression modelling was used to determine which study variables best
145 predict confidence in providing first aid in extreme conditions. Based on correlation results,
146 the non-modifiable characteristics, sex and age, were entered as the first step, followed by
147 previous emergency first aid experience and level of first aid qualification as the second step.
148 Test assumptions were met, with no evidence of homoscedasticity or non-normal error
149 distributions. Results indicated statistically significant models predicting EC-FACS scores.
150 Step 1 showed sex and age explained 10% of the variance in EC-FACS scores, adjusted $R^2 =$
151 $.10$, $F(2, 80) = 5.54$, $p = .006$. Step 2 revealed that experience providing first aid and level of
152 first aid qualification explained an additional 37% of the variance in EC-FACS, adjusted R^2
153 $= .47$, $\Delta F(4, 78) = 18.90$, $p < .001$. Table 4 shows the resulting model, explaining 47% of
154 variance in self-efficacy for extreme condition first aid skills. These results show first aid
155 experience was the strongest predictor of confidence in providing first aid in extreme
156 conditions.

157 **First aid training recommendations**

158 Most expeditioners (85%) agreed that further training would improve their confidence to
159 provide emergency first aid, and 94% indicated training tailored for the Antarctic
160 environment should be included before departure. The 76 expeditioners who stated that first
161 aid training should be included in pre-departure training, recommended 1—10 days ($M = 2.5$,
162 $SD = 1.6$). There was support amongst expeditioners for refresher training (64%) for
163 subsequent seasons rather than repeating full training courses.

164 There was a 44.4% response rate to open-ended comments regarding training and a 23.5%
165 response rate for comments concerning other relevant aspects. Content analysis of
166 participants' open-ended responses resulted in themes that are presented in Table 5. AAD
167 employed expeditioners questioned the consistency and quality of the required basic pre-

168 employment first aid certificate. Comments included, "...you can just sail through 'tick and
169 flick' style, in the fastest time for the smallest cost..." There were multiple comments that the
170 pre-employment first aid qualifications were inadequate for the Antarctic workplace.

171 Eighteen responses suggested advanced first aid training, such as wilderness first aid, as a
172 more suitable standard, some with reference to the wintering team, "...everyone in winter
173 team should have a minimum of wilderness first aid."

174 Some expeditioners noted standard wilderness first aid courses contained material that was
175 not relevant to Antarctica eg. envenomation and more appropriate topics, tailoring first aid
176 training to the Antarctic environment and combining first aid training with other field and
177 search and rescue training and emergency equipment used on station in Antarctica was
178 deemed more valuable. Participants suggested refresher training to consolidate knowledge
179 and skills and be as realistic as possible by including scenario-based learning, "Regular
180 simulations during the winter with real-life scenarios will help to make the expeditioner more
181 confident in their first aid ability."

182 **Discussion**

183 This is the first known study to examine first aid preparedness of Antarctic expeditioners.
184 Findings showed over a third of expeditioner participants did not have up-to-date basic first
185 aid qualifications and reported feeling ill prepared for serious medical emergencies that might
186 occur in an isolated and potentially dangerous environment. It is noted participants may have
187 had various affiliations (eg external summer expeditioners), differing employment
188 relationships and associated recommended predeparture first aid requirements which could
189 affect first aid training currency. Participants provided suggestions to improve emergency
190 readiness.

191 Experience in providing emergency first aid was the strongest predictor of first aid self-
192 efficacy. This aligns with previous research demonstrating the positive effects of simulation
193 training on medical emergency skills^{24,25}. This credibly strengthens the case for more
194 scenario-based learning at all first aid training levels for expeditioners.

195 **We used Bandura's definition²⁶ of self-efficacy (i.e., the individual's belief that they can**
196 **succeed at a specific task) in evaluating expeditioners' confidence in providing first aid in**
197 **extreme conditions.** Expeditioners with basic first aid qualifications reported low self-
198 confidence for responding to a major trauma casualty and had lower overall confidence than
199 those with higher qualifications. This suggests emergency first aid experience and level of
200 first aid qualifications are important determinants of first aid self-efficacy, supporting the
201 argument that higher first aid training would improve first aid confidence²⁷. Unexpectedly,
202 women reported lower first aid self-efficacy than men, but that difference may be better
203 explained by variables beyond the scope of this study.

204 This study also demonstrated that time since first aid training was unrelated to expeditioners'
205 confidence to provide first aid. However, extensive research in first aid training has shown
206 retention of theoretical knowledge and practical skills following first aid training, for both lay
207 people and health professionals, declines with time^{28,29}. Similarly, the level of skills retention
208 after a 12 month interval since training is insufficient for the majority of lay persons²⁵.
209 Schumann et al.²⁹ conducted a detailed analysis of wilderness first aid knowledge, self-
210 efficacy and skills retention at varying intervals following training. The work showed that
211 without repeated practice, skills and knowledge degraded over time and demonstrated the
212 more complex a skill the greater the deterioration in performance. These studies have
213 implications for Antarctic expeditioners, especially those wintering, where deployment times
214 may be greater than 12 months. A structured ongoing first aid training program utilising

215 realistic scenarios throughout Antarctic employment would help counteract the degradation
216 of expeditioner first aid skills.

217 This study assessed self-efficacy in providing first aid care in an extreme environment as it
218 was not practical to measure actual behaviours in the field. Previous authors such as
219 Schumann et al³⁰ have found no significant associations between self-efficacy and
220 performance while studies by Anderson et al³¹, and Carter et al³² have found self-efficacy as
221 an important predictor of actual skills. Experience is also strongly related to self-confidence
222 and performance and some studies have shown individuals become overconfident in their
223 abilities³³. Therefore, these results should be interpreted in that light – that the participants
224 may have overstated their levels of ability in performing first aid actions in an extreme
225 environment. Anderson and colleagues'³¹. Recommendations for refresher training, to
226 improve both self-efficacy and performance, would appear to be highly appropriate for first
227 aid training for extreme environments.

228 **Limitations**

229 This mixed method study provided quantitative and qualitative evidence on first aid readiness
230 of Antarctic expeditioners. The response rate was not high and overrepresented by year-long
231 expeditioners and while the sample size was adequate for performing study analyses, the
232 statistical power was limited. A potential reason for a lower response rate by non-wintering
233 expeditioners may reflect the fact they are less confident with first aid and hence why they
234 did not participate in the survey. In addition, it was not possible to test actual extreme
235 condition first aid skills to further understand what predicts successful first aid in those
236 situations. A large retrospective study might provide further evidence on these factors.

237 **Conclusions**

238 This study found many expeditioners did not possess minimum current first aid
239 qualifications. More advanced first aid training such as wilderness first aid training prior to
240 departure is recommended. Discrepancies in the quality and currency of expeditioner first aid
241 training when commencing preparation for expedition could be addressed by site-specific
242 contextual Antarctic training. Ongoing revision of skills to equip expeditioners with
243 emergency first aid skill set relevant to the Antarctic context indicate that an effective path
244 forward would be developing environment-specific first aid training curriculum delivered in-
245 house or in collaboration with external agencies.

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250 **Author Contributions:**

251 Study concept and design (JW, SB, KH)

252 Obtaining funding N/A

253 Acquisition of the data (JW)

254 Analysis of the data (JW, SB, KH, JS)

255 Drafting of the manuscript (JW, SB)

256 Critical revision of the manuscript (SB, KH, JS & JA)

257 Approval of final manuscript (SB, JA, KH)

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