Black Saturday: the immediate impact of the February 2009 bushfires in Victoria, Australia

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ABSTRACT

Objective: To examine the response of the Victorian State Trauma System to the February 2009 bushfires.

Design and setting: A retrospective review of the strategic response required to treat patients with bushfire-related injury in the first 72 hours of the Victorian bushfires that began on 7 February 2009. Emergency department (ED) presentations and initial management of patients presenting to the state's adult burns centre (The Alfred Hospital [The Alfred]) were analysed, as well as injuries and deaths associated with the fires.

Results: There were 414 patients who presented to hospital EDs as a result of the bushfires. Patients were triaged at the emergency scene, at treatment centres and in hospital. National and statewide burns disaster plans were activated. Twenty-two patients with burns presented to the state's burns referral centres, of whom 18 were adults. Adult burns patients at The Alfred spent 48.7 hours in theatre in the first 72 hours. There were a further 390 bushfire-related ED presentations across the state in the first 72 hours. Most patients with serious burns were triaged to and managed at burns referral centres. Throughout the disaster, burns referral centres continued to have substantial surge capacity.

Conclusions: Most bushfire victims either died, or survived with minor injuries. As a result of good prehospital triage and planning, the small number of patients with serious burns did not overload the acute health care system.

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The Victorian bushfires in February 2009 rank second among Australia's worst natural disasters (Box 1)[1] and among the top 10 wildfires/bushfires in the world with respect to fatalities (Box 2).[2] Before the "Black Saturday" fires of February 2009, bushfires in Australia had resulted in 642 recorded deaths.[3] Despite these tragedies, little has been published on bushfires (wildfires or firestorms), associated patient demographics and emergency medical responses.

On Saturday 7 February 2009, the state of Victoria experienced its hottest day on record, with the temperature in Melbourne reaching 46.4°C (116°F). Bushfires that had started in the heat across the state on that day intensified as a cool change came through in the afternoon, backed by winds gusting at up to 100 km/h. The major fires occurred in 14 different geographical regions and burnt an area of over 350 000 hectares (Box 3).

As part of its state emergency management arrangements, the state of Victoria has a mass casualty burns plan that aims to provide a clear framework for optimal care of burns survivors of a mass casualty incident.[4] The state response is linked in with a national burns plan (AUSBURNPLAN).[5] The importance of disaster planning exercises has been established,[6] and practice exercises have been conducted throughout the state.[7] The Black Saturday event represented an opportunity to critically examine the state's medical disaster response.

Our report examines the response of the Victorian State Trauma System to major bushfires from the perspective of the state adult burns centre and summarises the pattern of hospital presentations associated with the Black Saturday fires over the initial 72-hour period.

1 Deaths from Australia's worst natural disasters[1]

Year	Disaster/location	Deaths
1899	Cyclone Mahina, Cape York, Qld	>400
2009	**Victorian bushfires**	**173**
1852	Gundagai floods, NSW	89
1983	Ash Wednesday bushfires, Vic and SA	75
1939	Black Friday bushfires, Vic	71
1974	Cyclone Tracy, Darwin, NT	64
1967	Tasmanian bushfires	62

NSW = New South Wales. NT = Northern Territory. Qld = Queensland. SA = South Australia. Vic = Victoria. ◆

METHODS

Setting

The state of Victoria has a population of 5.2 million people. Ambulance Victoria is the authority responsible for providing prehospital care and coordinating medical treatment at the scene of an emergency, consistent with state emergency management arrangements and the State Health Emergency Response Plan. In addition, Ambulance Victoria provides triage at the emergency scene and primary and secondary air or road transport for victims.

Victoria is serviced by a statewide trauma system that includes two adult major trauma centres in central Melbourne (Royal Melbourne Hospital and The Alfred Hospital [The Alfred]) and one paediatric major trauma and burns centre (Royal Children's Hospital).[8] The state's adult burns service is located at The Alfred.

Definition of major burns

In non-mass-casualty situations, a burn of over 10% of total body surface area (TBSA) is considered an indication for admission to a specialist burns unit.[9] The Victorian State Trauma System, AUSBURNPLAN[5] and the Victorian mass

Abbreviations

E&TC	(The Alfred) Emergency and Trauma Centre
ED	Emergency department
ICU	Intensive care unit
TBSA	Total body surface area

2 Deaths from wildfire/bushfire disasters worldwide[2]

Year	Location	Deaths
1871	Peshtigo, Wisconsin, USA	1200
1918	Cloquet, Minnesota, USA	453
1894	Hinckley, Minnesota, USA	418
1881	Thumb region, Michigan, USA	282
1997	Sumatra, Kalimantan, Indonesia	240
1916	Matheson, Ontario, Canada	233
1949	Landes region, France	230
1987	Greater Hinggan, China	213
2009	**Victoria, Australia**	**173**
1825	Miramichi, New Brunswick, Canada	160

casualty burns plan[4] define a severe burn as a burn to 20% or more of TBSA in adults and children.

Data collection

The Alfred Trauma Registry is funded as part of the Victorian State Trauma System and collects trauma data concurrent with inpatient episodes. Data on all admitted bushfire victims and summary reports were provided to clinicians as early as 8 February and regularly updated. These reports formed the basis of the injury epidemiology data reported here.

We conducted a retrospective review of the strategic response required to treat patients with bushfire-related injury in the first 72 hours of the February 2009 bushfires in Victoria. We also contacted all hospitals in the vicinity of the fires to identify any burns- or bushfire-related attendances over the 72-hour period, allowing us to collate all potential emergency department (ED) presentations and hospital admissions. Data from the major trauma centres were analysed to obtain demographic features of patients with severe injuries.

Statistical analysis

SISA Binomial software (D G Uitenbroek, 1997) was used for all statistical analyses. Continuous data were reported as mean (SD) for symmetrical data or median (interquartile range [IQR]) for asymmetrical data.

Ethics approval

Our study was approved by The Alfred Ethics Committee as a quality improvement project.

RESULTS

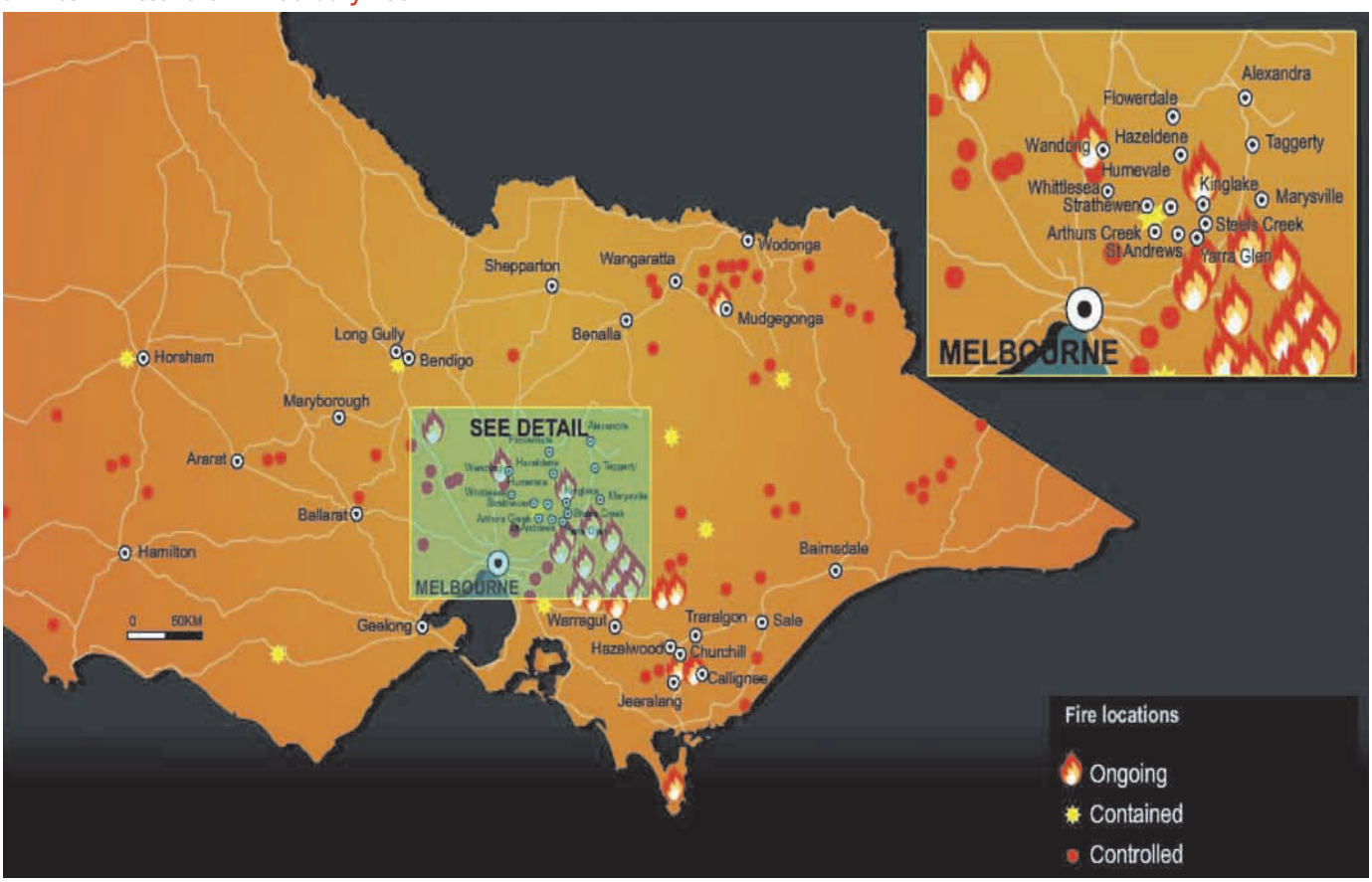
Statewide disaster response

Based on the risk profile of the prevailing weather conditions, the State Health Emergency Response Plan was activated by Ambulance Victoria at 08:00 on 7 February 2009, before any incidents had occurred. This enabled the Ambulance Emergency Operations Centre to plan, pre-deploy resources, and place other agencies on standby in the notification phase.

At about 20:00 on the same day, The Alfred was mobilised to accept major burns patients. Initial unconfirmed estimates indicated that more than 100 people had sustained severe burns, with a large proportion having non-survivable injuries.

The Alfred Emergency and Trauma Centre (E&TC) was initially staffed by three consultant emergency physicians, two advanced trainees in emergency medicine, two hos-

3 Fires in Victoria on 9 February 2009*



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4 Bushfire-related emergency department presentations within the first 72 hours of the Victorian bushfires*

	Burns referral centres†	Other Victorian hospitals	*P*
Disposition			
Total presentations	24	390	
Admissions to ICU/CCU	12 (50%)	11 (3%)	< 0.001
Admissions to general or burns wards	11 (46%)‡	77 (20%)	0.018
Transfers	0	6 (2%)	< 0.001
Discharges	1 (4%)	295 (76%)	< 0.001
Deaths	3 (13%)	1 (0.3%)	< 0.001
Primary presenting complaints			
Burns to ⩾ 10% of TBSA	11 (46%)	6 (2%)	< 0.001
Burns to < 10% of TBSA	11 (46%)	118 (30%)	0.143
Physical trauma	2 (8%)	62 (16%)	0.215
Smoke inhalation only§	0	42 (11%)	< 0.001
Other	0	162 (42%)	< 0.001

CCU = coronary care unit. ICU = intensive care unit. TBSA = total body surface area. * Figures represent number (%) of patients. † The Alfred (adult) and the Royal Children's Hospital (paediatric). ‡ Includes one patient transferred to the ICU 39 hours after the admission of the first bushfire victim. § Does not include inhalation burns. ◆

pital medical officers and one intern. Of the 17 nursing staff on duty overnight on 7 February 2009, eight were trained in critical care. In addition, there were three senior nurses with expertise in burns and intensive care who responded from their respective wards.

By 21:00, an on-site hospital incident control team had been established at The Alfred, comprised of the Hospital Incident Commander, the Director Burns Service and Director Emergency Department. Regular (ad-hoc and scheduled) liaison was maintained between the Hospital Incident Commander and the Victorian Hospital Emergency Centre, enabling rapid flow of reliable information and implementation of decisions outside the hospital (eg, full ambulance bypass, patient transfers, patient load-sharing).

In addition, the burns team had assembled at The Alfred. The team included the Director Burns Unit, another two plastic surgeons with subspecialty burns expertise, two accredited plastic surgery registrars, a burns liaison nurse and a burns care coordinator. Social workers and public relations personnel were also present on site.

All patients with burns of ⩾ 20% TBSA would normally be admitted to The Alfred, in accordance with the Victorian mass casualty burns subplan. However, in view of the expected high load of burns patients, the hospital incident control team and Ambulance Victoria agreed, after discussion, to triage patients at the prehospital stage in order to limit presentations to The Alfred to patients with ⩾ 30% TBSA burns until the actual number of patients could be determined.

AUSBURNPLAN,[5] yet to be ratified, was nationally activated by the Victorian Department of Human Services and the Australian Government. As part of this response, Emergency and Trauma Services at the Royal Melbourne Hospital agreed to accept all other adult trauma patients as well as major burns patients if The Alfred reached capacity. Medical directors of interstate burns units were notified of the possibility of a mass burns casualty event in Victoria. As part of the State Health Emergency Response Plan activation, contact was also established with Victoria's Ambulance Emergency Operations Centre, which assisted in the prehospital triage.

In anticipation of problems with airway management of burns patients, a variety of airway instruments and fibreoptic bronchoscopes were transferred to the E&TC. Anaesthesia support on 7 February consisted of one consultant in the E&TC, one consultant to supervise the operating rooms, and three advanced anaesthesia trainees. One intensive care consultant and a registrar were also present in the E&TC.

The burns ward at The Alfred was cleared of all non-burns patients and patients stable enough to be moved. Additional ward capacity was created by allowing a more flexible nurse-to-patient ratio (normally 1 : 4) and the opening of an elective surgery ward utilising 16 beds. Two additional theatres and staff required for urgent burns-related surgical procedures were put on standby. These additional theatres were used for the week following the incident.

Non-burns patient presentations to the E&TC were substantially reduced after the implementation of full ambulance bypass — except for burns patients — at 21:00 on 7 February. All adult major trauma patients had been redirected to the Royal Melbourne Hospital, and surrounding hospitals took other time-critical patients. Over the first 3 days, the Royal Melbourne Hospital had a 100% increase in trauma presentations to the ED, resulting in an 81% increase in trauma admissions (27 patients) during this time. Frequent communication was maintained between the Royal Melbourne Hospital and The Alfred to ensure that workloads were at acceptable levels.

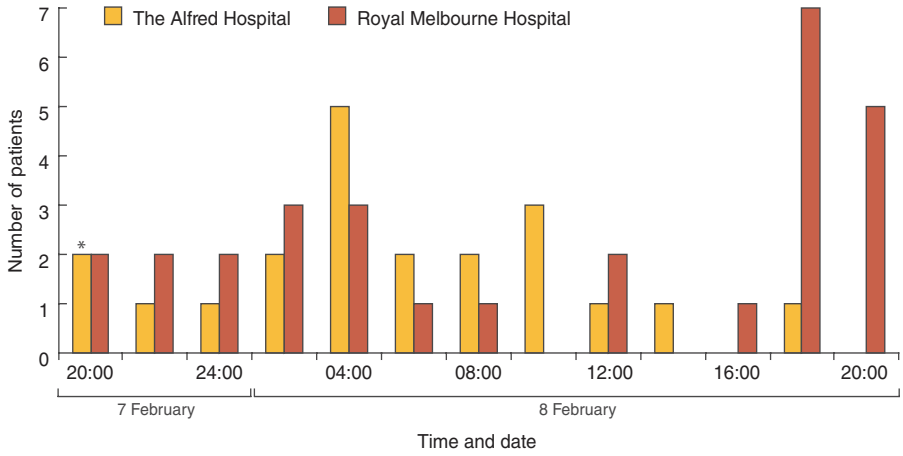
There were three available intensive care unit (ICU) beds at The Alfred on 7 February. As the number of critically ill patients was unknown, preparations were made to create as many ICU beds as possible. Over the next 36 hours, 10 additional ICU beds with normal staffing levels were created through downgrading patients to the high-dependency unit, discharges to wards, and one interhospital transfer. A further 15 cubicles were available if required, but were not staffed at that time.

On the morning of 8 February, the E&TC had a total of 13 patients, with a surge capacity of more than 30 burns patients. Staffing was staggered, with on-call staff notified and on standby. A teleconference that afternoon linked all involved EDs across the state for a briefing and strategy update. Over the course of the day, it became apparent that there were few, if any, severely burned survivors remaining in the community. The following day, reports from the scene suggested that further demand was unlikely to be high, and the E&TC came off bypass and resumed normal function at 08:00 on 9 February.

Patients

Presentations to the major burns referral centres and bushfire-related presentations to surrounding hospitals within the first 72 hours are summarised in Box 4. There were 20 presentations to the E&TC for bushfire-

5 Major burns and trauma presentations in the first 24 hours of the Victorian bushfires



* One patient with non-bushfire-related severe burns was admitted to The Alfred intensive care unit. ◆

related injuries — 11 primary presentations and nine transfers from other centres (Box 5). Eighteen patients had burn injuries. Fourteen of the 20 patients were men and six were women, with a median age of 53 years (IQR, 43–64 years) and a median Injury Severity Score of 13 (IQR, 4.0–27.5).

All patients with suspected airway burns and inhalation injuries were promptly intubated. All intubated patients underwent rapid flexible bronchoscopy in the E&TC to quantify the degree and severity of inhalation injuries. Ten patients were intubated either at the emergency scene, at the referring hospital or in the E&TC. Over the first 72 hours, 11 patients were admitted to The Alfred ICU, all of whom were mechanically ventilated.

On 8 February, two critically ill burns patients with < 30% TBSA burns, initially managed in the ICU of a major referral hospital, were transferred to The Alfred when it was clear that The Alfred ICU had created sufficient capacity. Thirty-nine hours after the admission of the first bushfire victim, another burns patient, initially admitted to the burns ward at The Alfred, had to be admitted to the ICU for ventilatory support.

In the first 24 hours, nine patients went to theatre for wound debridement, escharotomies and dressing of partial-thickness wounds with Biobrane (Bertek Pharmaceuticals Inc), a synthetic skin substitute. Theatre times required for surgical procedures on burns patients in the first 72 hours are summarised in Box 6.

Of the 20 patients managed at The Alfred, five had burns of ⩾ 30% TBSA, 12 had burns of < 30% TBSA, one had severe inhalation burns only, and the remaining two had non-burn injuries.

At the Royal Children's Hospital, four patients presented with burns from bushfires. Two were admitted to the ICU, one of whom had 80% TBSA burns and died.

DISCUSSION

The second-worst natural disaster in Australia's history and the worst since the introduction of the Victorian State Trauma System tested the emergency medical response and the burns plan of Victoria. Presentations of patients with severe burns were relatively few compared with the massive number who died in the fires. The statewide and national responses were triggered early and allowed the acute care medical system to cope well. Even though the number of patients with serious burns was small, the possibility of specialist burns and intensive care units reaching capacity was high.

There have been few reports on acute medical responses to bushfires. Carroll and Raiter reported on the 1918 Cloquet Fire in Minnesota,[10] while more recently Richardson and Kumar reported on the 2003 Canberra bushfires[11] and Vilke and colleagues on the firestorm in San Diego County, California, in 2003.[12] All three reports commented on the weaknesses in previous planning, and especially on the large numbers of patients presenting with minor injuries.

The capacity of Australian hospitals to respond to disasters has previously been questioned.[13,14] A major feature of the response to the February 2009 Victorian bushfires was effective prehospital triaging. This enabled the state's major referral centres to maintain considerable surge capacity. Other factors contributing to the relatively small numbers of injured patients presenting to the major trauma centres and statewide burns services included the presence of a rehearsed major burns plan, early communication, the significant distance of the major referral centres from the bushfires (thus enabling effective triage and minimising "walk-ins"), and a large number of supportive surrounding hospitals. Although TBSA ⩾ 30% was set as the initial triage criterion for referral to the major burns centres when the total number of burns victims was unknown, this was not followed, as it became apparent that the number of surviving victims was significantly less than first estimated. The value of varying normal criteria for referral to a burns centre requires further discussion, as patients may be disadvantaged by delayed referral.

There have been multiple reports on the stresses placed on burns centres during the September 11 terrorist attacks in the United States.[15,16] In a worst-case scenario,[5] Australia may need to be able to cope with a surge capacity of up to 300 severely burn-injured patients, in addition to the back-

6 Theatre times required for surgical procedures on burns patients at The Alfred Hospital in the first 72 hours of the Victorian bushfires

	Number of patients*	Theatre time, in minutes (hours)	Time per patient, in minutes (SD)
First 24 hours	9	723 (12.1)	80.3 (39.9)
Second 24 hours	6	1140 (19.0)	190.0 (74.1)
Third 24 hours	4	1058 (17.6)	264.5 (99.6)
Total	**19**	**2921 (48.7)**	**153.7 (98.7)**

* Five patients had two procedures. ◆

7 Major burns reception and resuscitation principles

A	Assessment of airway and burn coverage as proportion of TBSA
	Orotracheal intubation using ketamine, thiopentone and suxamethonium
	Subsequent orogastric tube insertion
B	Initial FIO_2 (fraction of inspired oxygen) 100%, with positive end-expiratory pressure
	Chest x-ray
	Bronchoscopy
C	Subclavian access (expect low central venous pressure)
	Arterial lines
	Adult diphtheria–tetanus vaccine
	Intravenous fluids (TBSA [%] × weight [kg] = mL of 0.9% NaCl to be given in first 2 hours)*
D	Plastic cling wrap over wounds
	Foley catheter with temperature probe
	Temperature control
	Intravenous gastric acid secretion inhibitors
Wound — early debridement/escharotomy/fasciotomy	
Early identification of major burns patients and notification of next of kin	

TBSA = total body surface area. * The Alfred formula: for example, a 60 kg patient with 20% TBSA burns would require 20 x 60 = 1200 mL of 0.9% crystalloid. ◆

ground incidence of severe burn injury (about 50 cases per week nationally). The AUSBURNPLAN template directs that each state and territory have a burns/mass casualty disaster plan to manage any acute surge of patients locally within the template. In a large-scale disaster, the Australian Health Disaster Management Policy Committee should play a key consultative role by liaising with all key stakeholders.

The early deaths in this disaster were most likely from direct effects of the fires, flames and radiant heat. There is little information regarding the effects of improvements in prevention and early warning systems on the patterns of burn injuries from bushfires. However, evidence from other natural disasters suggests that improved early warning systems would result in lower mortality and a higher number of patients reaching hospitals, with lower overall deaths.[17-21] It is hoped that the mortality profile from future bushfires will change in a similar way.

Our study was limited in that the data were not verified from all sites. It was unlikely that surgery for burns was performed outside the major burns referral centres, but this could not be confirmed. Examining the immediate impact on the primary care sector, which has been shown to be substantial in the past,[22] was beyond the scope of our report. Significant psychological effects of bushfires have been previously reported[23] and will require continued surveillance.

There are subtle differences between traditional management of major burns and management in the setting of a mass casualty disaster. The reception and resuscitation of the burns patients at The Alfred in February 2009 followed a standard approach (Box 7). As expected, most patients were hypovolaemic, and initial fluid resuscitation addressed this.[24] Wound management was performed according to standard practice, but on a much larger scale. First aid measures included the use of Burn Aid (Rye Pharmaceuticals) or plastic cling wrap to cover burn wounds before definitive wound assessment could be carried out by medical and nursing staff. In view of uncertainty regarding total numbers of patients and the extent of injuries, there were some variations from usual early operative management practice:

- Usual surgical practice (immediate transfer to the operating theatre for excision of burn wounds and wound closure with skin substitutes) was not instituted.
- Patients with a coherent history, clean partial-thickness burn wounds of < 10% TBSA and no history of dam immersion had their wounds cleaned and dressed in the E&TC. Escharotomies were performed in the E&TC on unconscious patients.
- Patients with extensive or contaminated burn wounds were transferred to the operating theatre for wound debridement, escharotomies and dressings.
- Definitive surgical management was planned and instituted once all patients for whom it was indicated had undergone "damage control" surgery (completed within the first 24 hours).

Patients requiring admission to the ICU were noted to differ from "usual" burns victims in two respects:

- The degree of early multiorgan system failures was higher than expected for the degree of burns; and
- The severity and extent of serious airway burns was much greater than usually seen, and was presumably related to the severe heat generated by the fires and the inhalation of dust and debris.

CONCLUSION

Most victims of the Victorian bushfires either died or survived with minor injuries. As a result of the coordinated response, the small number with serious burns did not overload the acute health care system. This pattern may change with improvements in forecasting and disaster planning, which could result in more survivors and greater stress on the acute health care system.

Moreover, the Australian Bureau of Meteorology has predicted warmer conditions in Australia's south-eastern states in the

8 Lessons from the February 2009 Victorian bushfires

- Bushfire disasters are characterised by high mortality and relatively few survivors with serious burn injuries. This is important in planning a disaster response.
- Prehospital triage is essential in managing the large number of minor ailments to avoid overloading the major burns centres.
- Ensuring the involvement of senior experienced personnel at the major burns centres enables rapid assessment and management.
- Even low numbers of patients with serious burns require substantial surgical resources during the first 72 hours.
- The Victorian State Trauma System and state burns plan allow reallocation of trauma and emergency patients, ensuring substantial surge capacity at major referral centres.
- The national burns plan (AUSBURNPLAN) provides further interstate surge capacity in the setting of larger disasters. ◆

future, making it likely that the conditions that led up to the Victorian bushfires will be repeated. Should fires occur and advance into more built-up areas, there may be a much higher number of deaths and severe injuries.

Lessons from the February 2009 tragedy (Box 8) as well as previous natural disasters must be used to strengthen prevention and medical response systems.

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COMPETING INTERESTS

None identified.

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