Australian Society of Plastic Surgeons

Mapping Burn Surgery in Australia

Contents

About this Report

The safe and successful management of serious burn injuries is a major challenge at any time for each patient and their family, the specialist workforce, major burns units, and the health and welfare system as a whole. Recent mass casualty burns events with major bushfires in Australia and volcanic eruptions in New Zealand have again highlighted the pressure under which services must work to manage routine caseload and a significant number of cases at one time due to regular, but unpredictable disasters.

In Australia, as with other western Nations including New Zealand, Canada, United States of America and the United Kingdom, burns services face a number of ongoing but evolving challenges, including ensuring that there is:

- nationwide access to specialist burns care routinely and during mass casualty events;
- a current workforce available and able to provide highly specialised multidisciplinary care covering all aspects of management, recovery and rehabilitation;
- the development and training of a replacement and future workforce;
- system development, research and leadership consistent with service demands and societal expectations; and
- funding that accurately matches the real cost of providing complex burn injury services.

At the moment there is some uncertainty about how well Australia is placed in meeting these challenges, therefore the Australian Society of Plastic Surgeons (ASPS) working jointly with the Australian and New Zealand Burns Association (ANZBA) and in collaboration with the Australian and New Zealand Paediatric Surgeons (ANZAPS) and General Surgeons of Australia (GSA) proposes to undertake this Project of mapping research of Burns Surgery in Australia.

Specific issues for consideration and analysis

The Sponsors and collaborating partners for this Project have identified the following key issues to be researched and analysed:

1. What are the different patient needs for burns surgery and related care and support in Australia?
2. Are there serious gaps in service provision in any part of Australia?
3. Which subspecialty surgeons (Plastic & Reconstructive surgeons / General Surgeons / Paediatric Surgeons) are treating major burns and in what proportion?
4. Which of these surgical subspecialties undertake advanced training in burns? Do all PRS trainees have substantive training in major burns units. What proportion of Paediatric and General surgical trainees have access to training in major burns units. Do surgical trainees only have some exposure to treating major burns during training instead?
5. Emergency Management of Severe Burns (EMSB) is the basic training course for immediate management of severe burns. Are surgical trainees completing this course?
6. Is there a current work force shortfall and if so, what is being done to train and recruit the next generation? Are there any Australian surgeons currently doing advanced burn training in Australia or overseas?
7. What are the options for organisational and workforce structure of major units? Do they need full time burns consultants to lead them?

8. What are the appropriate training, qualifications and expertise for junior and senior burns surgeons?
9. How is a career in burn surgery viewed by the prospective workforce?

Report Methods

The principal method of identifying and generating data and information for this report is through a comprehensive survey sent to the major Australian Burn Services, which report data to the BurnRegistry of Australia and New Zealand (BRANZ). The survey was developed based on the findings of the search of the literature, and analysis of local, national and international burn service guidelines and having regard for the various jurisdictional burn injury management plans and professional guidance.

The key terms used in the search were, largely grouped as follows:

Burn service:

- model of care;
- equipment, facilities, infrastructure;
- usual workforce.

Burn service workforce:

- surgical trainee burn surgery exposure and training;
- surgical trainee burn surgery career intention;
- burn surgeon future career intention.

An abbreviated questionnaire was emailed to the nominated head of major Burn Units which had not responded to an initial and second invitation to participate in the survey.

The webpages of the major burn units were scanned for information about models of care, usual caseloads and key workforce appointments. The grey literature was also searched as well as general media publications.

Australian Institute of Health Welfare (AIHW) data cubes for principal diagnoses and main procedures for hospital admissions and the National Hospital Cost Data Collection (NHCDC) were analysed for burn related admissions.

Key Findings

Patient Burn Needs

1. The network of major Burn Units in Australia and New Zealand, with models of care based on comprehensive multidisciplinary (MD) teams with access to up-to-date infrastructure, equipment and skin laboratories provides a strong and stable foundation to ensure access to high quality burn care.
2. The Major Burn Units in Australia manage about 45% of all burn injuries, and all paediatric major burns and almost all adult major burn injuries.
3. Substantial and ongoing community and professional education program ensures that patients are appropriately referred to both paediatric and adult Major Burn Units.
4. The number of designated and dedicated adult ward beds in Australian Major Burn Units per million population varies substantially between jurisdictions, with a rate in the range of 4.3 to 5.6 in Queensland, Tasmania, Western Australia and South Australia, but only 1.6 In Victoria and 3.1 in New South Wales (including ACT). The Victorian Adult Burn Service is based in a shared surgical ward, so has ready access to overflow capacity, but now almost occupies at least as many overflow beds as designated beds.
5. All paediatric Major Burn Units share ward space with other paediatric surgical wards, albeit utilising isolation and temperature and pressure-controlled rooms. These arrangements also allow the flexibility to manage mass casualty events.
6. First Nations people are about three times more likely to be admitted to a BRANZ hospital compared with other Australians and recent research has identified some gaps in cultural competencies and understanding in major Burn Units.
7. Significant advances in modern care have led to high rates of survival from major burn injuries, which in turn requires careful but sophisticated management to prevent scarring and has led to the development of complex treatment regimens requiring access to expensive lasers and other technologically advanced modalities and therapies.
8. The number of Burn Unit ward beds, based on adjustment to the current Victorian situation to bring it into line with NSW and with medium growth population projections, will need to increase to 85-91 from the current 69 beds to meet demand in 2033. The number of occupied paediatric beds is also projected to increase by about 20% to 23-24 beds.

Activity based funding and the cost of burn surgery care

9. In Australia public hospital Major Burn Units are funded through an activity based funding (ABF) arrangement using 10 diagnosis related groups. ABF is based on an average rate of reimbursement, which may be acceptable if there are a large number of cases with a normal distribution of complexity, however where there are relatively few very expensive admissions, for instance with DRG Y01Z (*patient ventilated for ≥96hrs or a tracheostomy for severe full thickness burns*), there is considerable adverse financial risk to the hospital. In 2021/22 the estimated reimbursement for a 17 day inpatient admission for Y01Z is about $188k, but only $198k for a 164 day admission. Detailed case costing undertaken at an Australian Major Burn Unit estimated that a 36 day admission for a major burn injury incurred costs in excess of $800k.
10. Individual Major Burn Units and their host hospitals are routinely exposed to considerable financial risk because of the in-built weaknesses of a small number of cases in high cost,

high complexity DRGs, where institutional cost accounting systems fail to identify all attributable costs.

Major Burn Unit surgeons, model of care and leadership

11. In Australia in adult Major Burn Units, with the exception of the Royal Brisbane & Women's Hospital (RBWH), surgery is almost entirely undertaken by plastic surgeons employed as sessional Visiting Medical Officers (VMOs), but with one Unit currently employing a full time plastic surgeon and another a full time general surgeon. RBWH has a general surgeon burn workforce. Major units may also have small fractional appointments for other subspecialist surgeons such as urologists.
12. Paediatic Major Burn Units have a mix of paediatric and plastic surgery VMOs, with three having a majority of paediatric surgeons and a paediatric director, with the other two having a predominantly plastic surgery workforce with a plastic surgeon head.
13. All Major Burn Units run a comprehensive multidisciplinary model of care with specialist nursing, allied health, anaesthetists, psychiatrists and psychologists, and subspecialist physician and surgeons, either directly employed or available on a consultative basis.
14. In Australia all Major Burn Units have a surgeon Director, whether a general, paediatric or plastic surgeon. These arrangements which are also preferred in North America and Europe have significant advantages in: participation by the Director in the burn surgery roster and on call; providing leadership and mentoring to the surgical workforce; sponsoring new surgeon recruitment; and influencing College and specialist society training policies.
15. Access to regular, planned elective surgery theatre lists ensures that care of patients with major burn injuries is organised, not rushed and optimised, and should be a minimum expectation in hospitals with Major Burn Units.
16. One adult Unit reported a relatively long-standing vacancy for a surgeon.
17. Pre-COVID no units reported particular problems in recruiting specialist nursing and allied health staff.

Burn surgery training and trainees

18. Exposure to burn surgery provided by enthusiastic burn surgeons at formative periods in medical school and during specialist surgery training can stimulate career interest in a clinical field which is often poorly understood by students and trainees.
19. Students in the final years of medical school and with an interest in surgery are particularly amenable to exposure to the management of patients with burns.
20. As noted, there are three surgical subspecialties who undertake burn injury surgery in the Major Burn Units, general (about 450 total trainees), paediatric (about 30 trainees) and plastic surgery (about 85 trainees). Minimum expectations for burn surgery training for:
    - general surgery is set out as part of the Trauma module, which is one of 17 training modules;
    - paediatric surgery is not specifically defined, but forms part of the broad training curriculum;
    - plastic surgery is set out in detail in the Burn and Cold Injury training module.

21. Paediatric and plastic surgery trainees are required to successfully complete the Emergency Management of Serious Burns (EMSB) course ideally before, or early in their training. General surgery trainees are not required to complete the course.
22. General surgery trainees, with the exception of rotations at RBWH are unlikely to undertake a formal term in burn surgery during their training. All paediatric surgery trainees can expect to have significant exposure to burn surgery training, as it represents a significant proportion of paediatric surgery caseload. Plastic surgery trainees must be able to demonstrate burn surgery competencies during the course of their training, which obviously requires exposure to this caseload.
23. Each of the Major Burn Units has a plastic surgery trainee assigned on either a shared or whole time basis. However in Australia plastic surgery trainees are not required to complete a substantive term at a Major Burn Unit, which stands in contrast to the mandatory requirements for New Zealand trainees to complete a rotation at the National Burn Service at Middlemore Hospital.
24. Worldwide there appear to be only a small number of Fellowship training posts, with few in Australia, however overseas-trained Burn Fellows are routinely employed in Australian Units.

Career and future work expectations of Surgical Trainees and Burn Surgeons

25. Current work conditions for surgeons and future career decisions for trainees appear to be closely tied to the structure of the burn surgery workplace. Recent research about plastic and burn surgeon burnout and factors influencing surgical trainee work expectations intersect around the employment model of surgeons.
26. Risk factors identified for burn out in plastic surgeons, include: a reconstructive rather than cosmetic practice; long work hours; on-call more than two nights a week; lack of professional autonomy; and a junior academic rank.
27. Plastic surgery trainee burnout was significantly associated with: a feeling of exclusion from involvement in Unit decisions; increasing hours worked; too much on call; being in the early years of training; working in units in which senior surgeons did not make weekly ward rounds and in which regular staff meetings were not scheduled.
28. A recent survey (2021) of RACS plastic surgery trainees found that the four most common impediments to a career in burn surgery were: the nature of burn operations; the nature of burn care; the expected level of on-call commitments; the adequacy of exposure and training in burn surgery.
29. The same survey found the current interest in a burn surgery at 49% compared favourably with a rate of 21% in a similar 2004 survey. 47% respondents were interested in a half time or sessional type appointment.

Key issues for consideration

a. Hospitals with Major Burn Units are likely to be at considerable financial risk from the level of reimbursement provided through activity-based funding alone. The average cost method for small volume, high cost, high complexity patients, has been recognised elsewhere as being inadequate, for instance in the funding of National and Statewide programs. There needs to be ongoing and coordinated responses from Major Burn Units and their host hospitals to Commonwealth and State jurisdictions to remedy these funding shortfalls.
b. Projected population increases will require about 20% more beds, both paediatric and adult by 2033, which will need to be addressed especially with respect to adult capacity in NSW and Victoria, given current bed numbers in those states.

c. Up-to-date, high-cost equipment is required at each centre to ensure patients can access the most effective, best practice, contemporary treatments, especially in relation to evaluating burn injuries and treating burn scars.
d. All Major Burn Units need an up-to-date workforce plan to ensure they have access to a specialist MD workforce now, and a succession plan for the future.
e. A qualified, specialist surgeon, depending on the type and composition of the Unit's surgeon workforce, is best placed to develop and promote the interests of the Burn Unit.
f. In most instances the flexibility afforded by a largely VMO burn surgeon cohort can help to reduce work pressures, the risk of surgeon burnout and present a model of care acceptable to prospective burn surgeons.
g. There would appear to significant advantages in increasing medical student and surgical trainee exposure to burn surgery.
h. Consistent with practice in New Zealand strong consideration should be given to ensure that all Australian plastic surgery trainees are required to be appointed to and complete a substantive rotation to a Major Burn Unit.
i. International burn surgery Fellows play an important role in bolstering the workforce in Major Burn Units. In turn Australian surgeons go overseas to complete formal Burn Fellowship training. It would be progressive if Australian Units working could either:
    i. work to establish a burn Fellowship training program for Australian surgeons in Australia; and / or
    ii. more explicitly develop an organised pathway to support Australian surgeons to train overseas and to facilitate return here after completion of their studies.

Model of Care

Modern burn care, informed by extensive research, has evolved substantially over the last few decades, with wide acceptance that best practice care of major burn injuries requires the coordination of sophisticated clinical services and potentially utilising resources across hospitals and health services. The physical, psychological and socials needs of burn victims necessitate the close collaboration of a broad spectrum of health care professionals, with the ultimate aim of providing patient-centred care and returning the patient to the optimal level of physical and psychological health and social function (Butler 2013).

High quality clinical outcomes are achieved through the use of standardised, efficient and effective operational procedures, that incorporate the planned coordination of a wide range of resources from the initial presentation of an acute injury through the often, many steps in long term care and rehabilitation.

Prolonged hospitalisation and the need for extended nursing and therapy is quantitatively different from other surgical services. The late outcomes of major burn injuries can have significant psychological effects, leading to considerable patient morbidity and a significant impact on return- to-work rates (Kastenmeier 2010). However markedly better survival rates have allowed major burn units to develop programs to improve burn patient long-term functional outcomes and quality of life.

Treatment and management of major burn injuries is therefore very resource intensive in terms of access to:

- a workforce, with burn expertise and competencies, that include nurse and allied health specialists, social workers, anaesthetists, the breadth of specialty and subspecialty surgeons and physicians, psychologists, psychiatrists and rehabilitation specialists;
- major hospital infrastructure including operating theatres, critical and high dependency care, and complex rehabilitation;
- specialised equipment, including lasers to measure burn depth and to assist the management of burn scars;
- complex dressings and other therapeutics; and
- a skin lab to participate in research to develop and make available skin substitutes to cover burn injury wounds.

Burn specialists are also best placed to undertake all levels of research in the field and to provide expert public health guidance about reducing the risk and incidence of burn injuries and widely promote best practice acute burn management.

Major Burn Units in Australia and New Zealand undertake research and quality improvement activities including submission of patient data and outcomes to the bi-national Burns Registry of Australia and New Zealand (BRANZ).

Burns Registry of Australia and New Zealand

The primary source of data about the management of burn injury patients in Australia is the Burns Registry of Australia and New Zealand (BRANZ), which is a clinical quality registry capturing epidemiological, quality of care, and outcome data for adult and paediatric burn patients across thirteen Australian and four New Zealand Burn Units (Tracy 2020, BRANZ 2021). It is expected that additional burn units will contribute data in due course.

The Registry was established to provide cohesive reporting across the two nations regarding burn epidemiology and treatment, with the aim of minimising the incidence and severity of injury and ensuring the best treatment for those who are injured.

The number of reporting institutions has increased from 12 in 2009/10 to 15 in 2015-16, then 17 in 2016/17 through to the 2019/20 financial year.

BRANZ captures data about all first admissions to an Australian or New Zealand Burns Unit within 28 days of injury where a burn is the principal reason for admission and one of the following criteria are met:

- the patient is admitted to hospital for a period of 24 hours or more; or
- the patient is admitted to hospital for less than 24 hours but requires a burn wound management procedure in theatre; or
- the patient dies within 24 hours of presentation to the BRANZ hospital.

The following referral criteria are endorsed by the Australian & New Zealand Burn Association (ANZBA) in assessing whether burns require treatment in a specialised Burns Unit:

- burns greater than 10% of total body surface area (TBSA);
- burns greater than 5% TBSA in children;
- full-thickness burns greater than 5% TBSA;
- burns to special areas (i.e., face, hands, feet, genitalia, perineum, and major joints);
- electrical burns;
- chemical burns;
- burns with an association inhalation injury;
- circumferential burns of the limbs or chest;
- burns in the very young, very old, or pregnant women;
- burns in people with pre-existing medical disorders that could complicate management, prolong recovery, or increase mortality;
- burns associated with major trauma; and
- non-accidental burns.

All Australian Major Burn Units have formal referral processes for assessing, and if required, accepting referrals from other hospitals. Telehealth arrangements allow staff at the Major Burn Units to provide support for other hospitals without the transfer of the patient.

Table 1 shows the annual number of first admissions by country over the last five years and the number of Units reporting data. The inclusion of an additional Unit in each country in 2016/17 had a substantial impact upon case numbers reported which increased by 17% in Australia and 9% in New Zealand, with the inter-year variation in case numbers in both countries occurring in a tighter band since then.

Table 1: BRANZ cases, 2015/16 – 2019/20 (source relevant BRANZ annual report)

Year	Australia (Units reporting)	NZ (Units reporting)	Total (Units reporting)
2015/16	2416 (12)	401 (3)	2817 (15)
2016/17	2821 (13)	437 (4)	3258 (17)
2017/18	2976 (13)	483 (4)	3459 (17)
2018/19	2844 (13)	437 (4)	3281 (17)
2019/20	2929 (13)	438 (4)	3367 (17)

Data reported for Australia for geographical area using the Australian Standard Geographical Classification (ASGC) shows in 2019/20 that the rate of burn injury per 100,000 people is higher in regional and remote areas compared with capital cities for both Indigenous and non-indigenous people. The rate of burn injury for Indigenous people is higher than for non-indigenous people for all geographic regions except in very remote areas.

Table 2: Rate of burn injury per 100,000 population, Indigenous status and Australian region, 2019/20

Region	Indigenous		Non-indigenous		Combined	
	Number	Rate	Number	Rate	Number	Rate
Major Cities	36	15	1,096	7	1,132	6
Inner Regional	46	30	471	12	517	12
Outer Regional	70	55	334	20	404	20
Remote	21	52	61	29	82	28
Very Remote	17	21	21	23	38	19
Total	190	29	1,983	9	2,173	9

Table 3 shows the summary rates for the four years from 2016/17 to 2019/20. The rate of burn injury in non-indigenous people was very similar year to year with the Indigenous rate having greater inter-year variation, but it was consistently around three times higher than the non-indigenous rate.

Table 3: Rate of burn injury per 100,000 pop, Indigenous status, Australian region, 2016/17-2019/20

Year	Indigenous	Non-indigenous	Total	Highest rate Indigenous	Highest rate non-indigenous
2016/17	33	9	10	67 (Remote)	35 (Remote)
2017/18	35	10	11	73 (Remote)	30 (Very Remote)
2018/19	24	9	9	77 (Remote)	39 (Very Remote)
2019/20	29	9	9	55 (Outer Regional)	29 (Remote)

The highest rates each year were in remote or outer regional areas for Indigenous people and remote or very remote areas for non-indigenous people.

In relation to caring for Indigenous patients with burn injuries, surveys (Fraser 2020) conducted of staff working in major Australian burn units identified that a Western biomedical health paradigm predominated, which used team experience, population data, evidence derived from a scientific understanding of care, expert information and direction from senior clinicians to determine model of care and allocation of resources. However, the authors concluded it would be beneficial if these methods were adaptable and modifiable to help formulate policy and practice in burns care

specifically for Indigenous children and families to encompass appropriate Indigenous constructs of health and wellbeing.

The extent of burn injury is measured in terms of percentage of total body surface area burned (TBSA). In 2019/20 the burn area for both paediatric and adult age groups was less than 5% in 65% of cases, with less than 3% of paediatric cases and 8% of adult cases having burn areas exceeding 20% (see Table 4).

Table 4: Percentage Total Body Surface Area Burned by Age Group, 2019/20 (BRANZ AR Table 16)

	Paediatric patients (0-15 years)		Adult patients (≥ 16 years)	
TBSA	Number	%	Number	%
0-4.9%	544	65	1,546	65
5-9.9%	186	22	404	17
10-19.9%	79	10	251	11
20-49.9%	19	2	148	6
≥ 50%	< 5	< 1	37	2

The extent of patient burns appears to be consistent year to year for both paediatric (see Table 5) and adult patients (see Table 6), with almost 90% of paediatric patients having TBSA of less than 10%.

Table 5: Percentage TBSA Burned - Paediatric patients (0-15 years), 2019/20 and four-year average

	0-9.9% TBSA		10-19.9% TBSA		≥ 20% TBSA		Total
Paediatrics	No.	%	No.	%	No.	%	No.
2016/17	875	88%	80	8%	38	4%	993
2017/18	884	89%	94	9%	20	2%	998
2018/19	829	92%	64	7%	13	1%	906
2019/20	730	88%	79	9%	20-23	2-3%	832
Average	830	89%	79	8%	23-24	2-3%	932

For adults about 82% of patients have TBSA of less than 10% and 7% have burn areas greater or equal to 20%, figures which were also consistent across the review period.

Table 6: Percentage TBSA Burned - Adult patients (≥ 16 years), 2019/20 and four-year average

	0-9.9% TBSA		10-19.9% TBSA		≥ 20% TBSA		Total
Adults	No.	%	No.	%	No.	%	No.
2016/17	1900	82%	256	11%	171	7%	2327
2017/18	2013	81%	283	11%	174	7%	2470
2018/19	1952	82%	270	11%	152	6%	2374
2019/20	1950	82%	251	11%	185	8%	2386
Average	1954	82%	265	11%	171	7%	2389

Table 7 provides details of the source of referral for BRANZ hospital patients. A substantial proportion of patients are appropriately referred from other hospitals, with all Australian BRANZ hospitals having a formal referral process which ensures and supports timely and appropriate patient referral. Survey respondents indicated that through extensive, and consistent statewide education programs, there was a clear understanding as to which burn injury patients should be referred to BRANZ hospitals.

Table 7: Referral source for registered BRANZ patients, 2019/20 (BRANZ Annual Report Table 20)

Referral source	Paediatric patients (0-15 years) No.	%	Adult patients (≥ 16 years) No.	%
Scene via ambulance	151	16%	457	19%
Other hospital	463	50%	1,059	43%
General practitioner	52	6%	151	6%
Self-presentation	96	10%	140	6%
Emergency department	0	0%	193	8%
Outpatients	107	12%	365	15%
Other source	55	6%	78	3%

Patient referrals though Outpatient Clinics raise the possibility that it may have been more appropriate for a proportion of these patients to have been referred at the time of the burn injury. One survey respondent from an adult unit noted that a number of these patients should have preferentially been treated initially at the Major Burn Unit.

Survey respondents did not think late referral of paediatric patients was a particular concern, with only small burns (1-2% TBSA) referred late, with this delay arising when a secondary centre is initially happy to manage the minor burn, but later refers due to greater burn depth than expected, or difficulty with dressing changes, or because of a parental request.

Access to critical care is an important aspect of care for a proportion of burn injury patients, in particular for those who sustain a major burn injury. Table 8 shows the proportion of all burn injury and major burn injury patients (paediatric >15% TBSA, adult >20% TBSA) admitted to intensive care units from 2017/19 to 2019/20 and the ten-year average from 2009/10 until 2018/19.

Table 8: ICU admissions, age group, burn severity. length of stay hours (median, IQR), 2017/18-2019/20

	Paediatrics (0-15 years)			Adult (≥16 Years)		
	% admitted – all patients	% admitted – major burn	LOS hours, median, IQR	% admitted – all patients	% admitted – major burn	LOS hours, median, IQR
2017/18	3%	48%	56 (28-299)	11%	77%	67 (30-221)
2018/19	4%	40%	57 (27-211)	10%	64%	60 (24-215)
2019/20	6%	44%	63 (23-228)	11%	76%	72 (27-208)
Av 2009/10-2018/19	4.4%	47.0%	64 (28-205)	12.8%	68.3%	64 (29-196)

The average median length of stay over the decade from 20019/10 of 2.7 days for both paediatric and adult patients, and the 75% interquartile average length of stay of 8-9 days confirms the key role critical care resources play in major burn injury care.

Table 9 provides a summary of key outcomes and indicators reported in the BRANZ annual reports for 2018/19 and 2019/20. BRANZ monitors and updates the data items collected (Gong 2021), utilising expert multidisciplinary clinical opinion and published literature. In 2016 the list of clinical quality indicators and data items was updated to 23 which cover structure, process, and outcome measures. At that stage four indicators were removed as not being useful, nine were revised, and eight new clinically useful indicators / data items were added.

In paediatric patients it shows improvements in 2019/20 compared with the previous year in rates of:

- gold standard first aid;
- enteral and parenteral feeding commenced within 24 hours;
- malnutrition screens; and
- planned and unplanned readmissions.

However there were deterioration in rates of:

- definitive assessment by a senior burn clinician;
- validated pain assessments;
- use of a burn diagram; and
- use of an accepted formula for fluid requirement estimation.

Table 9: Summary BRANZ outcomes and indicators, 2018/19 and 2019/20

Key indicator	Paediatric (0-15 years)		Adults (≥16 Years)	
	2018/19	2019/20	2018/19	2019/20
Gold standard first aid	71%	77%	61%	58%
Time to reach BRANZ hospital median and IQR	23 (4-173) hours	22 (4-142) hours	37 (6-140) hours	32 (6-130) hours
Major burn injury, transfer from scene direct to BRANZ hospital within 2 hours	nr	59%	nr	38%
Major burn injury, transfer from scene direct to BRANZ hospital	nr	72% in 3 hours	nr	91% in 7 hours
Definitive wound assessment by senior burn clinician within 72 hours of admit	98%	92%	97%	97%
Allied health physical assessment within 48 hours for patients with LOS > 48 hours	63%	63%	98%	95%
Validated pain assessment within 24 hours of admission	95%	89%	91%	97%
At risk of kidney injury or failure	4%	5%	3%	3%
Enteral or parenteral feeding within 24 hours of admission	63%	85%	70%	75%
Blood culture taken during admission	9%	10%	14%	13%
Percentage of blood cultures that are positive	7%	13%	15%	17%
Positive MRSA swab	2%	5%	9%	3%
Diagram used to determine burn size	66%	64%	74%	70%
Malnutrition screen within 24 hours for patients with LOS > 24 hours	57%	60%	80%	86%
Use of accepted formula use in fluid requirement estimation	91%	89%	86%	98%
Venous thromboembolism prophylaxis ≥16years	na	na	67%	70%
Readmissions with 28 days / proportion unplanned	15% / 24%	13% / 20%	5% / 54%	4% / 41%

In 2019/20 for adult patients there were improvements for the rate of:

- validated pain assessment;
- enteral or parenteral feeding started within 24 hours;
- malnutrition screens;
- use of accepted formula for fluid requirement estimation;
- use of VTE prophylaxis; and
- planned and unplanned readmissions.

There was a small reduction in the rate of physical assessments undertaken by allied health specialists and the rate of definitive wound assessments was maintained at very high levels of 97%.

In 2018/19, 79% of adults and 72% of paediatric patients underwent at least one burn management procedure in the operating theatres, this proportion fell to 68% for both patient cohorts in 2019/20 (see Table 10).

In adults more than 95% of these procedures involved debridement, with or without skin grafting. In the paediatric age group, 17% of operating theatre procedures were for dressing changes only, whereas in adults this represented les than 1% of procedures.

Only 1% of adult patients and less than 1% of paediatric patients required an escharotomy, fasciotomy or amputation in 2019/20.

Table 10: Operating theatre procedures, by age cohort 2019/20

Procedure type	Paediatrics	Adult
Procedures related to debridement		
Debridement only	21%	22%
Debridement and temporary skin closure product eg Biobrane™	13%	20%
Debridement and dermal reconstructive product eg Integra™ or other biodegradable temporising matrix	<1%	1%
Debridement and skin cell product	17%	10%
Debridement and skin grafting	48%	70%
Debridement and temporary skin closure with cadaver skin	<1%	4%
Other procedures		
Dressing change in theatre only	17%	1%
Escharotomy, fasciotomy, amputation	0%	1%
Other procedure	2%	2%

Burn Surgery Activity in Australia

In addition to the BRANZ registry data reported by the Major Burn Units other sources of national data provide context as to the level of burn injury in Australia. Referenced here are the National Hospital Cost Data Collection (NHCDC) and Australian Institute of Health and Welfare (AIHW) specialist reports, principal diagnosis and procedure data cubes.

In 2016 the AIHW and Flinders University released *Hospitalised Burn Injuries Australia 2013-14.* It found that there had been 5430 burn injury cases in Australia that year, of which 2319 were reported by the then twelve Australian BRANZ hospitals. The 5,430 cases led to 8,055 separations (1.49 / case) and 23,880 procedures (4.4 / case; 2.9 / separation). The AIHW report categorised cases as high threat to life (HTTL) using predicted mortality risk of 6% or higher and low threat to life (LTTL) (Stephenson 2003). HTTL injuries if not fatal are likely to have a large impact on the patient, often with persisting problems and ongoing need for health-care services.

The AIHW report estimated that in 2013/14 in Australia:

- there were 850 HTTL cases representing 15.7% of total 5,430 cases;
- the mean length of stay (LoS) for HTTL cases was 17.3 days and 4,5 days for LTTL cases;
- the mean LoS per case for people aged 0-15 years was 5.5 days and 7.2 days for adults;
- there were 246 ICU admissions with an average stay of 141 hours.

Mapping these findings to BRANZ hospitals, if it is assumed that all the HTTL cases were admitted to a Major Burns Unit then for the 2,319 Australian cases in 2013/14 recorded by BRANZ:

- the 850 HTTL cases would represent 14,705 bed days;
- the remaining 1,469 Australian cases, would represent a further 6,610 bed days, for a total of 21,315 days.

If this mix of patient severity and average length of stay was applied to the 2019/20 BRANZ caseload of 2929 admissions, it would represent a total of 26,939 bed days equivalent to 87 beds at 85% occupancy. It is estimated that while paediatric patients represent about 27% of total number of cases occupy approximately 20% of bed days given the average shorter length of stay.

Table 11 provides additional information about the number of burn related episodes of care in public hospitals from the NHCDC data sets, for 2013/14 and from 2015/16 to 2018/19, the most recent year for which data is available. The annual number of admissions to private hospitals for these diagnosis related groups (DRGs) is in the order of 200-300 separations of less complex burn injury.

Table 11: National Hospital Cost Data Collection, Public Hospital separations, 2015/16 – 2018/19

DRG	DRG Description	2013/14	2015/16	2016/17	2017/18	2018/19
Y01Z	Vent ≥96hrs / Trach for Severe FT Burns	103	137	134	113	125
Y02ABC	Skin Grafts for Other Burns	2429	2791	2693	2642	2604
Y03AB	Other OR Procedures for Other Burns	1088	1254	1239	1658	1684
Y60Z	Burns, Transferred to Acute Facility <5d	484	489	476	489	489
Y61Z	Severe Burns	389	482	435	436	457
Y62AB	Other Burns	2912	3047	3058	3032	3120
All	-	7405	8200	8035	8360	8479

The progressive increase in the count of separations in the NHCDC is consistent with changes reported to BRANZ. The NHCDC data shows an annual 2.7% increase in the number of separations.

Table 12 shows the site of the burn injury by case numbers and bed occupancy from the AIHW Principal Diagnosis data cube for 2018/19 from the National Hospital Morbidity Database (METeOR ID: 641349). Overall these data identify more than 40,000 occupied bed days for almost 8,000 burn injury cases.

Table 12: Separations and occupied bed days, ICD sub-chapter T20–T25, 2018/19

ICD sub chapter	Paed Seps	Paed bed days	Adult Seps	Adult bed days
T20 Burn of head and neck	303	1115	856	4325
T21 Burn of trunk	380	1510	752	7020
T22 Burn of shoulder and upper limb, except wrist, hand	270	708	882	4838
T23 Burn of wrist and hand	484	911	1030	3494
T24 Burn of hip and lower limb, except ankle and foot	360	1081	1376	9177
T25 Burn of ankle and foot	338	1093	885	5184
T26 Burn of eye and adnexa	16	20	146	213
T27 Burn of respiratory tract	2	5	41	287
T28 Burn of other internal organs	23	151	75	292
T29–T31 Burns of multiple and unspecified body regions	0	0	25	105
Total	**2176**	**6418**	**5781**	**34038**

Table 13 shows data from the AIHW Procedure ACHI for 2018-19 from the National Hospital Morbidity database (METeOR ID: 676382) on burn injury procedures by age group, with 39% of paediatric patients and 19% of adult patients admitted as day cases for procedures.

Table 13: Burn injury procedures, same day and overnight, by age cohort, 2018/19

Sub-chapter procedure codes	Same day 0-15 Years	O/N 0-15 Years	Total ≥16 Years	Same day ≥16 Years	O/N ≥16 Years	Total ≥16 Years
30010 Dressing of burn < 10% of TBSA dressed	415	303	719	57	420	477
30014 Dressing of burn ≥10% of TBSA dressed	25	146	171	9	211	220
45054-00 Escharotomy	0	10	10	3	50	53
1627 Debridement of burn	244	656	900	332	1887	2219
1640 Allograft, xenograft, or synthetic skin graft	9	50	59	306	1373	1679
1641 Split skin graft to granulating burn site	30	16	46	17	63	80
1643 Split skin graft to burn of specific sites	94	147	241	199	775	974
1644 Split skin graft to burn of other sites	155	282	437	287	1496	1783
1648 Full thickness skin graft to burn	25	40	65	86	94	180
1656 Revision of burn scar or contracture	114	99	213	232	255	487
Total number of procedures	**1112**	**1748**	**2860**	**1527**	**6625**	**8152**

Funding of burn injury care

Australian public hospitals are funded using activity-based funding (ABF) where an average cost has been determined for each of about 800 DRGs. In 2021/2022 the ABF payment for each unit of activity (NWAU) is $5597. The payments are adjusted annually but three years in arrears. There are 10 DRGs that are specifically assigned to burn injury related admissions, Table 14 shows the

expected average length of stay, the low and high boundary length of stay for inlier payments and the average high outlier per diem.

Table 14: Burn DRG metrics, inlier and outlier payments, 2021/22

DRG	Average length of stay	Low boundary days	High boundary days	Maximum payment low outlier	Inlier payment	High outlier payment per day
Y01Z	29.7	18	164	$188,567	$198,963	$3,725
Y02A	19.1	5	53	$42,682	$52,366	$2,588
Y02B	7.6	2	23	$12,706	$22,855	$1,989
Y02C	3.0	1	9	$0	$8,208	$2,500
Y03A	4.5	1	13	$0	$10,033	$1,987
Y03B	1.6	1	5	$0	$4,418	$2,334
Y60Z	1.3	1	4	$0	$3,419	$1,790
Y61Z	4.1	1	10	$0	$4,927	$1,288
Y62A	5.2	1	14	$0	$8,885	$1,619
Y62B	2.4	1	7	$0	$3,817	$1,686

The use of average costs has proven problematic for hospitals which have a relatively small number of high cost and high complexity cases, whether for major burn injuries or other conditions. By way of example, DRG Y01Z (*patient ventilated for ≥96hrs or a tracheostomy for severe full thickness burns*) the consequences are set out in Table 15. There are on average only about 125 cases assigned in Australia each year. The inlier payment is based on average length of stay, however there is an extreme span between the low and high boundary points of 146 days. The highest average daily payments accrue for shorter stay admissions up to the low boundary point of 18 days, with total payments on day 17 of $188,567 at an average daily rate of $11,092. The ABF payment from day 18 to 164 is fixed at $198,963, which at the high boundary point represents an average of just $1,213 per day which clearly is an improbably low amount to meet the daily care costs of major burn injury patients.

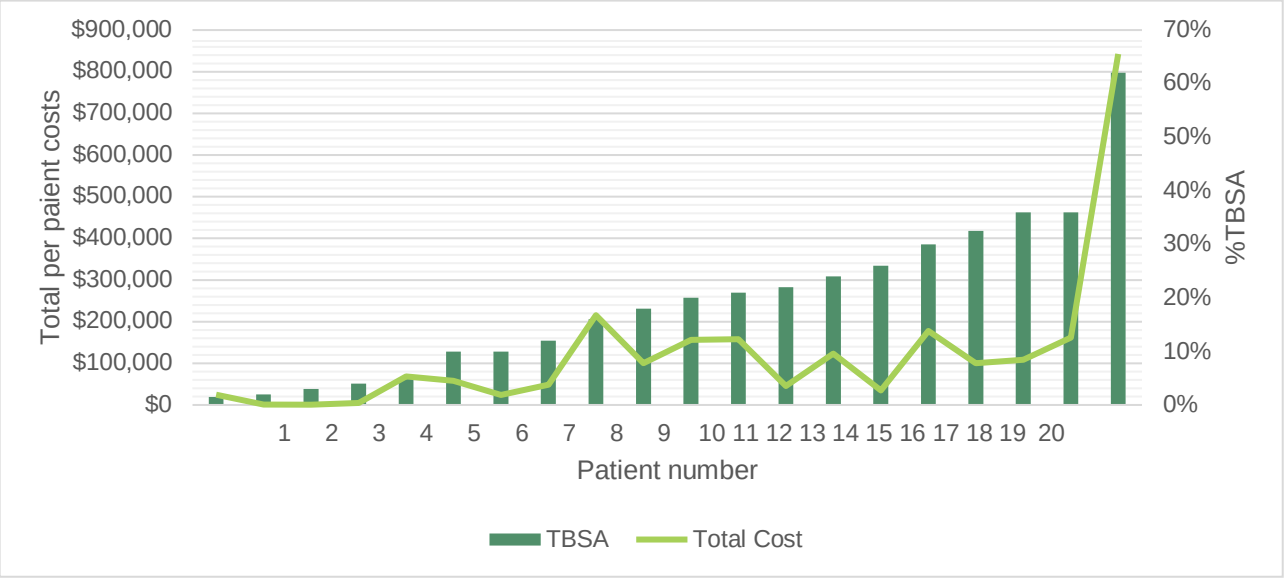
Table 15: Activity based funding payment schedule, DRG Y01Z, 2021/22

Day of admission	Total ABF payment	Average daily payment	Day of admission	Total ABF payment	Average daily payment
1	$22,234	$22,234	12	$136,588	$11,382
2	$32,629	$16,315	13	$146,984	$11,306
3	$43,025	$14,342	14	$157,380	$11,241
4	$53,421	$13,355	15	$167,776	$11,185
5	$63,817	$12,763	16	$178,172	$11,136
6	$74,213	$12,369	17	$188,567	$11,092
7	$84,609	$12,087	18	$198,963	$11,053
8	$95,005	$11,876	29	$198,963	$6,861
9	$105,400	$11,711	164	$198,963	$1,213
10	$115,796	$11,580	165	$202,688	$1,228
11	$126,192	$11,472	166	$206,413	$1,243

A study (Ahn 2012) at a Major Burn Unit set out to achieve an accurate calculation of the cost of acute burns care in an Australian context. It involved a retrospective review of 20 adult burn

patients treated at the hospital. An itemized price list was prepared based on items, services and equipment actually used in the care of burns patients. Case records were reviewed for a count of quantities to calculate costs for each item. Regression analysis was performed to produce a cost vs %TBSA curve for cost prediction. Using a direct cost attribution method established a daily bed cost in 2012 of $13,110. The cost calculated for an average adult burns patient was $71,056. The %TBSA was confirmed as the primary determinant of cost. Hospital length of stay, operative costs, dressings and staffing were found to be the most significant components of cost and increased in line with increases of %TBSA. Figure 1 shows the costs per patient. In this study patients 2 to 4 did not have an overnight inpatient stay. Patient 20 had an inpatient length of stay of 36 days, while accruing total costs in 2012 of more than $800,000, which is more than four times the payment in 2021/22, potentially for patient with much longer admissions.

Figure 1: Estimated patient cost, %TBSA (derived from Ahn 2012)



The risk of funding shortfall under ABF is further exemplified in that the next five cases with highest costs (9, 12, 14, 16, 19) had an average estimated cost of $166,000 and average length of stay of 8 days. In DRG terms these cases would likely code as Y02A, which in 2021/22 has an inlier payment of $52,366, a difference of $114,000 per case.

Current bed capacity and projections

In the mainland Australian states the adult Major Burn Units have dedicated ward facilities, which are not shared with other specialties, with the exception of The Alfred Hospital Melbourne, which shares a 34 bed ward with other surgical specialties. The Burn Service at Royal Hobart Hospital has two designated single rooms on a shared adult surgical ward and access to two paediatric beds.

Table 16 shows the number of Major Burn Unit beds for estimated resident population aged over 15 years. The population of New South Wales and ACT are combined to recognise patient flows and service availability.

Table 16: Major adult burn unit bed count, rate per 100,000 population, 2020

Jurisdiction	Population aged over 15 years, 2020	Number unit beds	Number of beds / million population	Projected increase in adult population 2020-2033
NSW + ACT	7098880	22	3.1	11%
Victoria	5547030	9	1.6	22%
Queensland	4183762	18	4.3	20%
Western Australia	2128218	10	4.7	22%
South Australia	1438470	8	5.6	10%
Tasmania	437974	2	4.6	6%
Northern Territory	197391	nr	nr	18%
Australia	21031725	69	3.3	17%
Australia excl Victoria	15484695	60	3.9	15%

On a population basis the number of adult beds in Victoria in the Major Burn Unit appears to be substantially lower compared with other jurisdictions noting that it is readily able to increase bed numbers because of the flexible shared ward configuration. However the number of formally assigned ward beds appears to be about half of New South Wales and only 40% of the rest of Australia.

Population projections out to 2033 (ABS 2019, no. 3222.0, medium projections) estimate an increase in the adult Australian population of about 17%. For the purpose of these projections if the Major Burn Unit beds in Victoria were increased to 18, to bring the national total to 78, then on a population only basis, there would need to be a minimum of 91 adult beds in 2033 to manage increase demand. This assumes that there is already capacity redundancy factored into the bed numbers in at least some of the jurisdictions to allow occupancy of 85-90%.

Using an alternative method to estimate future resource need, Table 17 shows the current rate of admissions to BRANZ major Burns Units from 2015/16 through to 2019/20. As noted above an additional Unit in both Australia and New Zealand started contributing data in 2016/17. The rate of admissions per 100,000 population has been calculated for these years. From 2016/17 the Australian rate ranged from 11.4 to 12.1, with an average of 11.7. In New Zealand the range was from 8.8 to 10.0, with an average of 9.3

Table 17: Admissions to Major Burn Units, per 100,000 population, Australia and New Zealand

Year	Estimated population Australia	Australian patients	Rate / 100,000 population	Estimated population NZ	NZ patients	Rate / 100,000 population
2015/16	23815995	2416	10.1	4609400	401	8.7
2016/17	24190907	2821	11.7	4714100	437	9.3
2017/18	24601860	2976	12.1	4813600	483	10.0
2018/19	24982688	2844	11.4	4900600	437	8.9
2019/20	25688676	2929	11.5	4979200	438	8.8
Year	**Projected population**	**Projected number**	**Rate**	**Projected population**	**Projected number**	**Rate**
2023	27047951	3165	11.7	5022400	467	9.3
2028	29051673	3399	11.7	5460500	508	9.3
2033	30512645	3570	11.7	5679000	528	9.3

Using this average rate and the same projected population increases (ABS 2019, no. 3222.0, medium projections) and Stats NZ shows an estimated increase in the number of patients receiving treatment at Major Burn Units in Australia in 2033 compared with 2020 of 641 (increase of 22%) patients and in New Zealand 90 patients (increase of 21%).

Ideally inpatient wards with multi-day stay patients with immunocompromised and high risk patients, should not be expected to operate at occupancies beyond 85%, as time must be taken to ensure safe patient transfers, clean beds and equipment and allow sufficient redundancy for staff to undertake required quality and safety protocols.

If the previously calculated mix of patient severity and average length of stay was applied to the projected caseload of 3,570 admissions in Australia in 2033, it would represent a total of 32,822 bed days an increase of 5,583, which at 85% occupancy represents 18 beds. The total estimated minimum requirement in Australia in 2033 would therefore be under this method 106 beds, of which about 80% would be adult (85 beds), with 21 paediatric beds. These estimates are broadly consistent with the simple, population-based projections.

These methods project the number of beds in Australian Major Burn Units at 85-91 in 2033, an increase of 23-32% on current numbers, noting the relatively low number of beds in Victoria. Paediatric beds are estimated at about 20% of the total and therefore would be in the range 21-23.

Burn surgery training

International experience

In North America Shih (2019) and colleagues undertook a retrospective review of 55 graduating plastic surgery residents in Canada over a ten-year period. Case logs showed an average of 73 burn and burn-related care procedures for each resident, accounting for 6.8% of an average of 1080 total procedures logged. Ninety-nine percent of the logged burn procedures were core procedural competencies (CPCs). The most frequently performed procedure was harvest and application of autograft, allograft, or xenograft, while emergent procedures such as escharotomy and compartment release were performed on average less than one time per resident. Personal competence scores as well as role of the resident increased with progression through the residency.

A US study of applicants for the final surgery qualifying exam found that they had an average and median 10 months of experience in surgical critical care, trauma and burn rotations, representing about one sixth of their five years of training. Of this the burn rotation duration was a mean of 0.8 and median of 1.0 months (Napolitano 2016).

A review of UK plastic surgery trainee experience (Highton 2017) for 336 specialty registrars found that over the six-year training program, trainees participated in an average of 2117 procedures, performing an average of 1571 procedures with / without supervision. The average weighted mean number for burns resuscitation cases performed was 39, compared with an expected number in 2012 of 18 and an ongoing projected number in 2016 of 18. The number of excisional burn or emergency burn operations performed was an average 85, compared with an expected 63 and revised number of 60 cases. The new indicative numbers were set at approximately one standard deviation below national mean number of procedures performedduring training using the eLogbook data. Statistically, 84% of trainees would be expected to achieve this target. The target of 78 burn surgery cases represents 4.1% of total expected plastic surgery procedures.

In the US the Accreditation Council for Graduate Medical Education (ACGME 2014) specifies that plastic surgery trainees must perform a total of 24 integument burn procedures, of which 16 are burn reconstructions. Review of the ACGME requirements for general surgery and paediatric surgery did not specify any target number of burn surgery procedures.

Drawing on a comparison of plastic surgery training in the United States and Europe (Kamali 2016) Highton (2017) drew up the following table, which provides information on the new annual intake, the extant number of plastic surgeons and the expected total number of trainee operations. Additional information has been added for Australia and Canada.

Table 18: Comparison of plastic surgery trainee intakes and log book requirements

	USA	Ger	Neth	UK	Fra	Spa	Ita	Pol	Aust	Can
New annual Intake Trainee (pmp)	148 0.45	nr	16 0.94	10–20 up to 0.30	25–30 up to 0.44	37 0.79	39 0.66	32 0.84	17 (ASPS 2021) 0.65	30 (Morzycki 2018) 0.77
Plastic surgeons / 100,000 population	1.98	1.94	1.71	0.79	1.11	2.09	1.30	0.50	1.81 (RACS 2016)	1.55 (Morzycki 2018)

	USA	Ger	Neth	UK	Fra	Spa	Ita	Pol	Aust	Can
Total trainee operations	1150	640	600	2100	nr	560	nr	450	nr	1050 (Shih 2019)
Burn surgery operations	24	nr	nr	78	nr	nr	nr	nr	nr	73

Source: Highton 2017

The number of plastic surgeons per capita in Australia is mid-way between Canada and USA, but more than twice the number in the UK. The annual intake of new plastic surgery trainees in Australia at 0.65 per million population is substantially higher than USA, UK and France, but less than Canada, Poland, Spain and the Netherlands.

Burn surgery training in Australia

The Royal Australasian College of Surgeons (RACS) has adopted competency-based, rather than time-based only surgical training programs, which in turn have been applied by the designated professional societies to the specific specialty. RACS has established ten domains of competence - technical domains (Medical expertise, Judgement and clinical decision-making, and Technical expertise), and non-technical domains (Leadership and Management Professionalism, Communication, Health Advocacy, Scholarship and teaching, Collaboration and Teamwork, Cultural competence and safety). The specialty surgery curricula guides assessment of trainees in all of these domains, as well as providing direction as to what level of competence should be attained both during, and by the completion of, the training program.

In Australia major burn surgery is performed by members of three surgical specialties:

- Paediatric Surgery – 28 trainees;
- General Surgery - 455 trainees; and
- Plastic and Reconstructive Surgery – 82 posts, 87 trainees.

Paediatric Surgery

Paediatric Surgery is numerically the smallest of these three specialties, with currently 29 trainee posts, spread over the various years of training.

Table 19: Paediatric surgery training program posts, 2021

Hospital / Health Service	Number of trainees	Major Burn Unit	Major Paediatric Trauma Service
The Canberra Hospital	1	No	No
John Hunter Children's Hospital	1	No	Yes
Sydney Children's Hospital Randwick	3	No	Yes
The Children's Hospital Westmead	4	Yes	Yes
Gold Coast University Hospital	2	No	No
Queensland Children's Hospital	4	Yes	Yes
Townsville Hospital	2	No	No
Adelaide Women's & Children's Hospital	2	Yes	Yes
Monash Health Melbourne	2	No	No
Royal Children's Hospital Melbourne	5	Yes	Yes
Perth Children's Hospital	2	Yes	Yes

Twenty-one of the twenty-nine posts are located at hospitals with Major Paediatric Burn Units. Trainees are required to undertake training in at least two geographic regions.

The publicly available curriculum for paediatric surgery (RACS 2021) provides no explicit description of the expected competencies for paediatric surgery trainees. It does however specify that experience and competence should be gained in examples of common conditions (including but not exclusive to) each of the following:

- neonatal surgical conditions;
- trauma and burns, including prevention and management;
- the abdomen;
- abdominal wall, hernia and inguino-scrotal conditions;
- head and neck;
- skin, subcutaneous tissue and extremities;
- tumours occurring in childhood; and
- thoracic (non-cardiac).

Paediatric surgery trainees are required to successfully complete the following courses:

- Advanced Paediatric Life Support (APLS) Courses
- Early Management of Severe Trauma (EMST) Course
- Care of the Critically Ill Surgical Patient (CCrISP) Course
- Training in Professional Skills (TIPS) Course
- Emergency Management of Severe Burns (EMSB) Course prior to their training starting or by the end of early SET.

Information provided by two major Paediatric Burn Units demonstrate different approaches according to the senior surgical staff profile. Where paediatric surgeons lead the Unit the paediatric surgery trainees are significantly involved in the management of burn injury patients, with between one third and two thirds of the trainee complement formally linked to the paediatric burn surgery service. One paediatric surgery trainee attends every elective burn surgery list and multidisciplinary team meeting. All trainees participate on the emergency on-call roster.

At the other hospital the clinical workload is split between plastic surgeons who have predominant responsibility for hand and face burn injury and scar reconstruction, with other burn injuries managed by the paediatric surgeons. The paediatric surgery trainees spend part of their time in the Burn Unit.

General Surgery

The management of burn injury in the General Surgery curriculum is set out in the Trauma Module, which is one of seventeen modules. It is expected that the graduating general surgery trainee will be able to, amongst others:

- describe the pathophysiology of shock, acute brain injury, respiratory failure, sepsis, renal failure, multi-organ failure and burns;
- identify appropriate treatment options, and their indications and contraindications;
- participate in a trauma team including in the team leader role;
- safely and effectively assess and resuscitate the injured patient;
- implement the principles of:
    - Early Management of Severe Trauma (EMST) / Advanced Trauma Life Support (ATLS);
    - Care of Critically Ill Surgical Patients (CCrISP); and

- Definitive Surgical Trauma Care (DSTC);
- have a clear understanding of the potential disaster, humanitarian and military responsibilities of general surgeons;
- disaster planning;
- epidemiology and prevention; and
- trauma quality improvement, benchmarking and audit trauma systems and resources allocation.

The expected competencies at the various SET levels in the General Surgery Trauma Module are set out in Appendix 1. The technical operative expertise in early SET includes compartment pressure measurement, wound exploration and debridement, wound closure or open management, split skin grafting and VACC therapy. In mid SET the competencies include escharotomy and local flap coverage.

Plastic & Reconstructive Surgery

In 2021 there were 82 Plastic & Reconstructive Surgery training posts. Table 20 lists where they are distributed, clearly not all work in Burn Units. Each of the mainland Adult Burn Units led by a plastic surgeon have a plastic surgery trainee who is appointed as an 0.8 to 1.0 FTE. In Tasmania burn surgery management is an integral part of the overall plastics workload, but the trainee is not appointed wholly to the Burn Unit, with its caseload and emergency on-call also shared with a number of non-accredited registrars.

Table 20: Plastic surgery trainee rotations 2021

	Major Burn Unit Adult	Major Burn Unit Paediatrics	Other hospitals	Total
NSW	Concord -1 RNSH - 3	TCHW - 1	17	22
Victoria	Alfred - 3	RCHM - 2	20	25
Queensland	RBWH - 3	QCH - 2	8	13
WA	FCH – 2	PCH - 2	7	11
South Australia	RAH - 3	AW&CH - 1	5	9
Tasmania	RHH - 1	0	1	2
Total	**16**	**8**	**58**	**82**

Both the plastic surgery trainees at Perth Children's Hospital work in the Burn Unit and there also are supported by a number of non-accredited service registrars.

Trainees are expected to manage burn patients from first presentation and initial resuscitation, through acute management to meeting their long-term reconstructive needs, for both minor and major burn injuries, and both functional and cosmetic aspects.

Trainees are also expected to manage more complex scenarios such as inhalation injuries and burns in the setting of polytrauma and to be able to perform emergency treatment such as escharotomies and tracheostomies.

Burn surgery competencies are set out in the Burn and Cold Injury module (see Appendix 1) of the curriculum. Early SET trainees are expected to be able to:

- perform an accurate assessment of burn wounds (extent and depth);
- debride minor burns; and
- perform skin grafts for minor burns.

Mid SET trainees are expected to be competent in:

- escharotomy and fasciotomy;
- debride and dress major burns, including the use of temporary skin cover;
- perform skin grafts to specialised areas (eg hands and face);
- perform a tracheostomy;
- design flaps for burn contracture release.

Late SET trainees are required to perform:

- use skin substitutes for burns and reconstruction;
- perform distant and free flaps for acute burns and burn reconstruction.

Importantly while all Major Burn Units in Australia have dedicated plastic surgery trainees, not all trainees undertake a substantive appointment at one of these Units during the course of their training. This stands in comparison with New Zealand requirements that all plastic surgery trainees must complete a term at the National Burn Unit at Middlemore Hospital.

Major Burn Unit facilities, organisation, leadership and workforce

The information in this section has been sourced from:

- the survey undertaken for this report, which had a moderate response rate, but with detailed information provided. Responses were received from three of the six major adult burn units, two of the five paediatric units and one of the two combined units;
- the comprehensive paediatric hospital and burn unit websites; and
- other web searches including peer reviewed and grey literature and reports.

All the major burn units are integrated in major trauma networks, however Concord Hospital and Fiona Stanley Hospital are not major trauma hospitals but have organisational arrangements to manage this situation.

For the twelve major burn units where detailed information was available, all have adopted a multidisciplinary team approach which of specialized burn surgery, specialist burn nursing staff, the breadth of allied health disciplines, rehabilitation and other medical specialties usually on a consultative basis.

Facilities and infrastructure

There have been new hospital builds relatively recently (last ten years) at the following sites:

- Perth Children's Hospital;
- Fiona Stanley Hospital;
- Royal Adelaide Hospital;
- Royal Children's Hospital Melbourne;
- Royal Hobart Hospital;
- Royal North Shore Hospital; and
- Queensland Children's Hospital;

which has ensured that these sites have modern, purpose-built facilities, with single rooms with pressure and temperature controls needed for the management of major burn injury patients.

The larger adult units have routinely scheduled operating lists, but smaller units require access emergency surgery lists or scheduled plastic surgery lists to treat burn injury patients. All units have access to critical care and intensive care facilities.

Improvements in acute burn care have enabled patients to survive major burn injuries that would have once been fatal (Finnerty 2016). Now up to 70% of patients develop hypertrophic scars after burns which often have long-term consequences for quality of life and return to work.

Compression garments, massage, laser therapy, intense pulsed light, steroids, exercise, and injection of fat into the scar have been used to reduce hypertrophic scar (Friedstadt 2014), with a combination of these usually needed. The incorporation of laser and light therapy can reduce hypertrophic scar by decreasing erythema, reducing height, and increasing pliability of scar (Hultmann 2015). Additional benefits included reduced pain, pruritus, colour, and abnormal texture. Non-ablative or ablative fractional lasers have become a standard therapy reduce stiffness in hypertrophic scar by inducing collagen remodelling. The pulsed dye laser, the ablative fractional CO_2 laser, and intense pulse light reduce particular aspects of the hypertrophic scar. Pulsed dye laser decreases vascularity by inducing necrosis in the targeted

capillaries leading to reducing scar volume, erythema, pliability, hyperaemia, itch, and pruritus (Finnerty 2016).

Major Burn Units therefore also require access to up-to-date equipment to manage post-burn scarring to optimise the benefits of other life-saving advances in management of major burn injuries.

Burn unit surgical workforce

Paediatric Burn Units have the following staff configurations:

- The Children's Hospital Westmead - paediatric surgery lead, 5 VMO paediatric surgeons; 2 VMO plastic surgeons;
- Royal Children's Hospital Melbourne – paediatric surgery lead, 2 VMO paediatric surgeons; 1 VMO paediatric plastic surgeon;
- Queensland Children's Hospital – paediatric surgery lead, 7 VMO paediatric surgeons, 1 VMO paediatric urologist;
- Perth Children's Hospital – plastic surgery lead, 3 VMO plastic surgery, 2 VMO paediatric surgeons;
- Adelaide Women's & Children's Hospital – plastic surgery lead, 4 VMO plastic surgeons, 1 VMO paediatric surgeon.

All the Adult Burn Units, with the exception of Royal Brisbane & Women's Hospital (RBWH) have a plastic surgeon lead and all, or a significant majority of plastic surgery VMOs. RBWH has a general lead and additional VMO general/ trauma surgeons. It is also noted Major Trauma Services, which are not also Major Burns Units may receive patients with burn injuries, which are usually managed by general or trauma surgeons.

Detailed staffing was provided from six burns units, which is presented in Table 21. Some Burn Units have been successful in building up a significant surgical workforce whether of full time or VMO staff. The larger units are also significantly advantaged in having overseas Fellows who contribute substantially to managing the Unit caseload. The current pandemic border restrictions are however causing difficulties in enabling efficient recruitment and retention of international staff.

Table 21: Senior surgical staffing profile

Unit type	Annual admissions	FTE	Admits / FTE
Adult	300	2 FTE 1 Fellow, other VMOs	~75 / FTE
Adult	300	3.1 FTE VMOs Fellow	~75 / FTE
Adult	275	1.2 FTE 1 Fellow	~ 125 / FTE
Combined	100	0.5 FTE, other VMOs	~100 / FTE
Paediatrics	Not specified	1.9 FTE	~100 / FTE
Paediatrics	Not specified	1.0 FTE, 0.5 Fellow	~125 / FTE

Burn Unit head

The International Society of Burn Injury guidelines (2017) recognise that the specialty of the burn unit Director can vary depending on local conditions, however burn surgeons must maintain active decision-making responsibility and control of care for major burn injury patients. Surgical specialisation of the Director may be general or plastic with additional training in burn care, wound management, skin grafting and amputations, and depending on available resources advanced knowledge in critical care. The guidelines identify a failed model as one where intensivists have primary responsibility for the patient, with a consultative role for the burn surgeon when surgery is deemed necessary.

The 2017 European Burns Association guidelines provide more explicit recommendations, in that the Director should be a medical specialist dedicated to and experienced in burn treatment, familiar with all aspects of complex and continuous burn care, with at least 10 years of clinical practice, taking responsibility for all activities at the burn unit. Formal education could be as a plastic surgeon, general surgeon, anaesthetist or intensivist. Surgical background though is preferred, as the causal treatment of severe burns is done with surgery.

In the United States, a 2017 survey of burn surgery units (Egro 2019) found that 69% of unit directors were general surgeons, a third of whom had completed additional burn surgery fellowships. Burn surgery and wound care was undertaken by general surgeons in 51% of units and plastic surgeons in 42%. With respect to future recruitment desirable qualifications were identified as general surgery (67%) and / or plastic surgery (41%) with additional fellowships in burn surgery (55%), trauma surgery (15%) or critical care (44%). The survey found that the Director's primary surgery qualification had a substantial influence on their recruitment preferences.

Currently in Australia the heads of the major Burn Unit are surgeons, of the subspecialty the provides the predominant proportion of the surgical workforce. For the adults units the Burn Unit lead is a specialist plastic surgeon, except at RBWH which has a general surgery lead. In the major paediatric units, there are plastic surgery leads in Adelaide and Perth, with paediatric surgery leads in Melbourne, Sydney and Brisbane.

The clear advantages of having a specialist burn surgeon as the Director of the Unit are:

- able to model to other staff the primary responsibilities of a burn surgeon;
- availability to participate in all clinical aspects of burn surgery, including roster, on-call, outpatients and multidisciplinary care;
- able to provide leadership, mentorship and collegiate support to other burn surgeons;
- able to effectively promote the Unit to prospective surgeons;
- able to contribute to key research and development strategies;
- better placed to work with RACS and professional societies to influence trainee curriculum.

Overall its very likely that the advantages of having the most appropriately qualified surgical Director of the Burns Unit, whether plastics, paediatrics or general, depending on local circumstances, would outweigh any other considerations.

Burn Unit workforce planning, recruitment and retention

As identified Major Burn Units are structured and staffed to provide complex multidisciplinary care, with ongoing monitoring needed to ensure that the current composition meets the needs of the Unit and that there is a broad understanding of the future work intention of each health

professional and the workforce as a whole. The model in place whilst important in its own right for the current workforce in terms of retention, will also likely have a significant impact upon the attitudes of prospective staff and the success of future recruitment.

With respect to the burn surgeon workforce there are broadly three main models: all sessional visiting medical officers (VMOs), mixed VMO and full time surgeons, or an all full time workforce. The workforce in all three forms can be substantially buttressed by International Burn Fellows, who may be available either on a part time or fulltime basis, but who do not impose a long term obligation on the Unit. All the models have advantages and disadvantages, which may change over time, which will in turn influence the risk profile for staffing the Burn Unit.

All Burn Units have a finite amount of total remuneration available to employ staff in general and burn surgeon staff in particular. In Australia larger units have about 3 FTE surgeons and a full time or half time Fellow. Total head count is important in spreading the on-call load, with a minimum of 5 or 6 surgeons needed to fully cover the roster, especially when surgeons are on leave. The availability of Fellows on time limited contracts is an important lever in managing the on-call roster. Table 22 presents possible staffing mix, with 3 FTE surgeon.

Table 22: Surgeon and workforce appointment and staffing mix models

Number full time FTE	Number of VMO FTE	Total Head count
3 FTE, one of whom is Head	0 VMO	3
2 FTE, one of whom is Head	2 VMOs each at 0.3 FTE; 1 VMO at 0.4 FTE	5
1 FTE	1 VMO 0.6 head of unit, 2 VMOs each at 0.4 FTE, 2 VMOs each at 0.3 FTE	6
0 FTE	1 VMO 0.6 head of unit, 2 VMOs each at 0.4 FTE, 3 VMOs each at 0.3 FTE, 2 each at 0.2 FTE, 0.3 FTE ad hoc	8+

Full time surgeons are currently employed in major Australian Burn Units, but according to their mode of employment, as a joint University / hospital appointee or only through the hospital, they are most likely to have an actual clinical appointment of 7 to 8 sessions each week, with the remainder of 2 to 3 sessions, explicitly designated for administration, teaching, research, private practice and other activities. The advantages of full-time appointments include:

- that one surgeon is available to cover a substantial block of the Unit's workload;
- the surgeon is usually on-site in-hours if emergency treatment of a patient is required;
- there is good continuity of care and clarity about clinical responsibility; and
- a presence within the hospital and university hierarchy, which can help in the promotion of the work and objectives of the Unit.

An appointment of a full time surgeon is particularly appealing if a Unit has had a period of some workforce and roster instability. A hospital's short-term interest in an employing a well-qualified surgeon who maybe a recently recognised, overseas qualified surgeon or an older local surgeon, with no current or future interest in private practice is fairly clear cut.

The main disadvantage relates directly to the key advantage, key-person dependence, in that undertaking a substantial block of work presumably with a significant on-call requirement can become a problem if the surgeon becomes unavailable because of sickness, holidays,

resignation or retirement, which will lead to a significant gap in the roster. A significant proportion of the burn surgeon budget is therefore locked into one or two key personnel, which reduces other employment flexibility.

Visiting Medical Officers are usually contracted for an agreed, remunerated number of sessions (usually of about 3.5 hours each), with principal responsibilities related to theatre, ward, outpatients and the on call roster. A VMO, if the Director of the Unit, may also be paid for an administrative session. However other VMOs are unlikely to have paid sessions not directly related to clinical care, notwithstanding likely participation in teaching, research and administration, which does allow for some free-riding by the hospital. Ideally VMOs should have a substantial appointment of three to four sessions each week, which demonstrates commitment to the service, provides for a robust service model including reasonable on-call, and helps with continuity of care. Other advantages therefore largely relate to the availability of a larger qualified surgical cohort:

- public workload is shared;
- less onerous on call demands;
- ensures leave entitlements are used;
- allows for diversification of interest and the development of a non-burn surgery private practice;
- increases breadth of surgical experience and expertise in the Unit;
- more easily allows internal re-allocation of sessions with changing surgeon interest, which also facilitates future leadership development;
- supports initial surgeon appointments to Burn Unit, with the reallocation of one session from a couple surgeons less impactful in them if they already have established private practices.

The issue of a having a substantially full-time appointment in smaller Burns Units, will further heighten the key worker loss.

The extant workforce model will have a significant influence on the perceived and actual attractiveness of the Unit to prospective surgeons.

Surgeon and trainee burnout

There has been a lot of recent international research about factors influencing retention of surgeons, with particular reference to surgeon burnout, which is characterised as a state of mental and physical exhaustion (Khansa 2015). In the research literature the dependent variable for professional burnout is measured by three subscales from the Maslach Burnout Inventory Human Services Survey. These are:

- emotional exhaustion;
- depersonalization; and
- feelings of reduced personal accomplishment (Prendergast 2017).

Studies (Streu 2014, Qureshi 2015, Santos 2020) have found more than a quarter of plastic surgeons and 40% of general surgeons, suffer from burnout, which can have negative repercussions for the surgeon, their family, patients and colleagues. Risk factors identified for plastic surgeons, include:

- a reconstructive rather than cosmetic practice;
- long work hours;
- on-call more than two nights a week;

- lack of professional autonomy; and
- a junior academic rank;
- being middle-aged; and
- having poor health.

Plastic surgeons with burn out also reported a nearly two-fold increased risk of self-reported medical errors and self-reported impairment (Qureshi 2015). There is also a significant overlap of burnout, depression, and substance abuse (Khansa 2015).

A 2020 survey of American burn surgeons (Sutherland 2021) found that 85-90% of respondents experienced burn-out, with women surgeons five times more likely to report burnout compared to male colleagues. The highest rates were in the 40-44 age group compared with older surgeons.

Professional burnout has also been investigated with respect to plastic surgery trainees (Grome 2021). Almost 150 P&RS trainees who responded to a survey (Coombs 2020) in the US found an overall burnout rate of 57.5%, and on average, all residents experienced work exhaustion and interpersonal disengagement. Burnout was significantly associated with respondents who:

- did not feel involved in Unit decisions;
- reported increasing hours worked;
- felt that they had too much on call; or
- reported making a major medical error that could have harmed a patient.

Consistent with these findings Hart (2020) found that 65.5% of plastic surgery residents met the definition of burnout by their scores from at least one of the Maslach Burnout subscales. The number of hours worked each week significantly correlated with increased scores in the emotional exhaustion and depersonalisation subscales. Burnout risk was increased in trainees in the early years of training, who were feeling dissatisfied with career plans or worked in units in which senior surgeons did not make weekly ward rounds and in which regular staff meetings were not scheduled (Chaput 2015). The occurrence of a weekly ward round by a senior surgeon appears to be protective against burnout (P = 0.007); regular staff meetings also appeared have a similar effect as they offered an opportunity to ask questions, and to receive follow-up, feedback and mentoring. Notwithstanding these findings almost 70% reported satisfaction with their careers (Chaput 2015).

Addressing burnout

The literature indicates that a two pronged approach is needed to addressing surgeon and trainee burnout, an individual one and an organisational response which can make the work environment more appealing to clinical staff.

At an individual surgeon level, interventions such as stress management, self-care, communication skills training, facilitated small group discussion, gratitude interventions, and professional coaching (Drybe 2019) have been shown to build resiliency, mindfulness and reflection. For surgical trainees, peer mentoring, professional development coaching, physical exercise, discussion of imposter syndrome, and having a general practitioner to support their well-being can help, though alone these will not necessarily reduce burnout (Sharpe 2017).

Organisational leadership qualities, attributes, and management styles have a direct impact on surgeon satisfaction and burnout. Transformational qualities and skills such as mentorship, coaching, instilling pride, discussing values and purpose, praising accomplishments, and

identifying individual needs and talents result in the highest rates of satisfaction (Menaker 2008, Shanafelt 2015).

Effective organisational interventions to reduce the risk of staff burnout include:

- strengthen individual professional autonomy;
- attention to workload and job demands, with the prospect of increased roster flexibility and shorter shifts;
- broader responsibility for on call;
- modifications to work processes and flows;
- optimisation of electronic health records;
- availability of support staff to undertake administrative tasks;
- optimisation of shared work spaces;
- certainty about allowable leave (holiday, sick, family, maternity, paternity);
- support staff access to self-care resources;
- team building exercises; and
- open and consistent dialogue between clinicians, Unit management and hospital administration.

Plastic surgery trainee work intentions

In the context of their current state of well-being and options for surgical careers, consideration of future work intentions feed into the overall equation for trainees and Burn Units as to how organisational and professional structures can positively influence these decisions.

Recent surveys of North American plastic surgery training programs (Vrouwe 2020) found that burn care was considered an important component in training by program directors (USA 88%; Canada 100%) and trainees (USA 87%; Canada 99%). Rotations for trainees averaged 2.5 months and most commonly occurred during the second year of training. Three-quarters of American residents were interested in a career that involved burn care in some capacity, primarily burn reconstruction (40%). Factors that discouraged North American trainees were:

- the nature of burn care (60%);
- the nature of burn operations (45%);
- the on-call commitment (39%); and
- a narrow scope of practice (38%).

A study of plastic surgery trainees in Canada (Morzycki 2018) asked them about their experience of the training program, specifically as to whether they would like to see more of a particular training domain and whether they intended to seek additional qualifications (see Table 23). Ninety-six percent of trainees had had a term in burn surgery during their training, with 7% interested in having further training exposure and 3% of trainees intending to seek further qualifications and Fellowship in burn surgery.

Table 23: P&RS Training domains, exposure and future training intention

Domains	Domain exposure during residency (%)	Domain would like to see more of during residency (%)	Domain intending to seek additional qualifications (%)
Hand/ Upper extremity	100	9	23
General principles	99	10	2
Breast surgery	97	3	11
Craniofacial	97	32	11
Pre-operative assessments	97	nr	nr
Post-operative assessments	97	nr	nr
General cutaneous disorders / burns	96	7	3
Research	88	10	0
Lower extremity reconstruction	86	32	2
Head and neck reconstruction	80	41	5
Aesthetic surgery/ body contouring	77	52	13
Medical education	74	17	3
Trunk reconstruction	74	32	2
Pelvic/ genital surgery	62	36	2
Microsurgery	nr	nr	8
Paediatric plastic surgery	nr	nr	5
Peripheral nerve surgery	nr	nr	2
Brachial plexus surgery	nr	nr	1%

A study of UK plastic surgery trainees (Fell 2020) found that in relation to first choice subspecialty, that 7% were interested in a burn surgery career (see Table 24)

Table 24: Plastic surgery trainees, first choice subspecialty intent

First choice subspecialty	Percentage
Hand and upper limb	20%
Cleft lip and palate	12%
Lower limb trauma	12%
Oncoplastic breast surgery	12%
Skin and sarcoma	10%
Burns	7%
Academic plastic surgery	6%
Head and neck oncology	5%
Craniofacial surgery	4%
Aesthetic plastic surgery	2%
Complex wounds	2%
Ear reconstruction	1%
Genito-urinary	1%
Pelvic reconstruction	1%
Vascular anomalies	0%

Surgical trainee intention remains a key determinant in building and maintaining the burn surgeon workforce. A recent survey (Sreedharan 2021) of 121 plastic surgery trainees (response rate 59%) in Australia and New Zealand, replicating the study of Brown (2004), found an increased interest in having a career in burn surgery. Thirty-three of seventy

respondents were interested in a half time or sessional type involvement, with one wishing to pursue a fulltime career. The current interest in a burn surgery of 49% compared favourably with a rate of 21% in the 2004 survey.

Sreedharan (2021) found that the three most common impediments to a career in burn surgery were the nature of burn operations and burn care, and the level of on-call commitments which were the same as the previous survey. A fourth factor identified related to the adequacy of exposure and training in burn surgery.

Exposure to a specialty in medical school has been shown to influence students' career choices. Medical students and early year medical post-graduates (Davis 2016, Johnson 2018) were found to have a greater interest in a career in plastic surgery with greater exposure to the discipline, in particular operating theatre time, and specialist surgeon interest and interaction with the student or junior doctor. A survey (Kahn 2011) of medical students found that significant predictors of interest in burn surgery were an interest in surgery ($P < .001$, odds ratio [OR] = 56.3), prior exposure to burn surgery ($P = .02$, OR = 5.7), which became a stronger predictor for fourth-year medical students ($P < .001$, OR = 24.5). The majority of students reported that exposure to burn surgery (76%) and a strong mentor (87%) would make them more likely to consider burn surgery as a career. The majority of students reported ignorance of the field of burns with three quarters not knowing enough about the field to consider it as a career. Exposure during medical school and strong mentorship may influence more students to become burn surgeons, with mentorship and recruiting efforts focused on students with a general interest in surgery. Brady (2018) also proposes mentoring to encourage plastic surgery trainees to develop skills and an interest in burn surgery.

Sreedharan (2021) identified that more comprehensive training exposure would provide additional confidence about developing a burn surgery career. It was noted that all New Zealand trainees are required to undertake a formal placement at the National Burn Unit at Middlemore Hospital, a requirement not in place in Australia. Survey respondents indicated that strong, early mentorship as a burn surgeon, supported by sufficient resources and funding would increase the attractiveness of a career in the field. The authors identified that the employment of more burn surgeons on a part time or sessional basis, rather than a full-time basis would address a major concern about on-call responsibility and increase the number of burn surgeons to spread the workload, which in turn would help mitigate the risk of surgeon burn out. An increase in the size of the workforce, coupled with additional training exposure provides a strong basis to provide the surge capacity needed during mass burn events.

Sreedharan estimated based on the number of P&RS trainees and an interest in a burn surgery career that over the next five years there would potentially be two P&R surgeons available to work for each of the 17 major burn units in Australia and New Zealand, which would represent about 13 FTE based on expressed work preferences.

Other members of the Multidisciplinary Burn Unit team

Surveys of North American and UK burn units have clarified future intentions about the burn surgeon workforce in the next ten years, with a substantial cohort of older surgeons considering retirement. These surveys also found that three quarters of Canadian burn units (Vrouwe 2018) were currently in need of additional specialist burn nurses, with the availability of nursing expertise cited as the most common barrier to delivering burn care. Similarly in the United States, 62% of major units had experienced a nursing shortage, with an average of almost five vacant positions. A French study (Ravat 2014) found excess time spent on administration de-incentivised nurses. In the review a third of nurse time in a large burn unit was occupied with

administrative tasks, a third of which was not clinically related and could be performed by administrative staff.

There needs to be a clear understanding of what factors support and hinder all members of the multidisciplinary team including specialist nurses, physiotherapists, occupational therapists, psychologists and social workers with a view to effective workforce planning that covers future intentions and recruitment strategies.

Appendix 1 – surgical training curricula

General Surgery Trauma Module Competencies

SET level	Medical expertise	Judgement and clinical decision - making	Technical expertise - operative management knows	Technical expertise – operative management does
Ongoing ICU management: definitive care phase				
Early SET	Definition and pathophysiology of traumatic shock, ischaemia reperfusion injury, post injury SIRS, sepsis and MOF, nutrition, compartment syndromes, burn care	Ability to perform focused assessment of theorgan systems based on clinical examination, vital parameters, laboratory data and the required level of organ support. Ability to indicate and interpret focused imaging required based on clinical assessment. Interpret compartment pressure measurements and know the indications fortreatment. Attention to prevention of common postinjury complications.		Compartment pressure measurement
Soft tissue and skin				
Early SET	Wound healing Pathophysiology of necrosis and ischaemia Pathophysiology of burns	Distal neuro-vascular assessment; Viability assessment of soft tissues; Burn assessment; Fluid resuscitation in severe burn patients;Inhalation injuries; Management priorities of acute traumatic wounds depending on mechanism, location and contamination; Initial management principles of severe burns; Anticipation and recognition of woundcomplications.	Surgical airway	Wound exploration; Wound debridement; Wound closure or open management; Split skin grafting; VACC therapy.
Mid SET		Advanced soft tissue management decisions: identifying the need for specialist involvement. Wound management in specific areas.	Wound management inspecific areas	Escharotomy; Local flap coverage.
Blast injuries				
Early SET	Understanding the unique patterns of blast trauma Pathophysiology of blast injury	Assessment and description of woundsIdentify life threatening injuries; Initiate initial resuscitation;		Lavage and debride contaminated wounds; Intercostal catheters.
		Assess tetanus immunisation status; Identify possible exposures to toxins, chemicals or radiological; Relevant investigations for barotrauma, penetrating, blunt and burn injuries.		

Mid SET		Mass casualty triaging; Resource allocations; Co-ordinate multidisciplinary team efforts; As per initial resuscitation phase and identify life threatening injuries; Management of contaminated wounds; Management of severe burns; Air embolism.	As per initial resuscitationphase and identify life threatening injuries.	Surgical airway; Thoracotomy; Emergency laparotomy; Haemorrhage control; Escharotomy in burns.

Plastic and Reconstructive Surgery - burn and cold injury module competencies

SET level	Applied Medical expertise	Clinical Assessment	Management	Technical expertise
Early (SET 1-2)	Able to discuss: Burn depth • pathophysiology of burn injuries • thermal (hot and cold) • electrical • chemical Timing and rational for antibiotic useTiming of initial surgery Resuscitation options Fluid regimes The benefits and disadvantages of both earlyexcision and conservative management. Nutritional support Microbiology of burn wounds Extravasation injuries. Outline the features and management of toxicepidermolysis syndrome. Outline the criteria for transfer of a patient to a burns unit.	Elicit a targeted history from apatient presenting with burns. Conduct a focused physicalexamination to assess the severity of the injury. Recognise life-threatening injuries and septic shock. Assess the vascular status of alimb. Assess the presence of compartment syndrome. Select and interpret appropriate preoperative investigations. Determine whether transfer to burn unit is required. Assess the psychological impact of burns trauma for the patient and refer appropriately.	Apply a range of burn dressings. Manage acute minor burns. Resuscitate a burns patient. Apply knowledge of fluid resuscitation in the management of paediatric burn patients and implement paediatric fluid regimes. Plan burns excision and grafting. Plan release of burn scars using grafting and local flaps. Use simple scar management techniques including splints andpressure garments.	Perform an accurate assessment of burns wounds (extent and depth). Debride minor burns. Perform skin grafts for minor burns.
Mid (SET 3-4)	Explain the pathophysiology of inhalation and burn injury. Describe the management of patients with specific burn injuries (e.g., inhalation, chemical and electrical burns). Discuss: • principles of early burn debridement • principles and management ofburnand relevance to subsequent soft- tissue reconstruction • management of inhalation injury including bronchoscopy	Recognise non-accidental burn injuries and refer to appropriate services. Clinically assess burn scars and contractures, demonstrating recognition of injury patterns.	Prescribe appropriate antibiotics. Formulate management plans for patients with common patterns of burn injuries. Plan total and staged burn excision and grafting. Facilitate end-of-life decisionmaking with patients and families. Effectively lead initial resuscitation of a major burn.	Perform escharotomy and fasciotomy. Debride and dress major burns, including use of temporary skin cover. Perform skin grafts to specialized areas (e.g., hands,face). Perform a tracheostomy. Design flaps for burn contracture release.

SET level	Applied Medical expertise	Clinical Assessment	Management	Technical expertise
	• metabolic response to burn injury. Demonstrate knowledge of: • options available for early surgery • requirements of special sites • principles of management of more complex injuries including polytrauma planning and prioritising treatment in a multidisciplinary setting. Demonstrate knowledge of the differences in aetiology and pathophysiology between adult and paediatric burns patients. Demonstrate knowledge of the differing role of burn facilities, units and centres and integration with major trauma.			
Late (SET 5)	Demonstrate knowledge of principles and use of dermal and epidermal substitutes, including stem cells, cultured epithelial autografts, and other emerging technologies.		Formulate a reconstructive plan for patients with a major burn injury, considering a range of reconstructive techniques and priorities.	Use skin substitutes for burns and reconstruction. Perform distant and free flapsfor acute burns and burn reconstruction.

Appendix 2 - Major Burn Unit survey

The survey was developed based primarily on Australian and international guidelines, and the terms of reference for the project,

	Example Reference	**Rationale**	**Expected data source**
1. Respondent	N /A	Allows follow-up	Survey respondent
2. Service Lead	British Burn Association, European Burns Association	Influences structure of service, new appointments, development of future workforce	Survey respondent
2. Type of appointment	British Burn Association, project terms of reference	Provides indication of workforce structure, options for service development	Survey respondent
3. Hospital division	Project terms of reference	Demonstrates key organizational relationships	Survey respondent
Activity and Caseload			
4. Admissions, LOS, proportion major burns	BRANZ data	Provides an estimate of usual demand	Survey respondent
5. Proportion referred from another hospital	BRANZ data	Provides an estimate of usual demand	Survey respondent
6. Proportion referred meet ANZBA guidelines	Estimate based on BRANZ data, professional estimate	Provides an estimate of usual demand	Professional estimate made by respondent
7. Proportion of referring hospitals comply with referral guidelines	Estimate based on BRANZ data, professional estimate	Provides an estimate of usual demand	Professional estimate made by respondent
8. Estimate of proportion of patients not referred	Carmichael 2019; professional estimate, based on late referrals post-discharge from another hospital to ED, OP	Provides an estimate of non-referral, to help identify opportunities to improve patient care, to help project additional Burn Service demand	Professional estimate made by respondent
9. Proportion of burn patients admitted to critical care, LOS	BRANZ data	Provides an estimate of usual demand	Survey respondent
10. Proportion of admissions with at least one major burn management procedure	BRANZ data	Provides an estimate of usual demand	Survey respondent
11. Number of OP attendances	British BurnAssociation	Provides an estimate of usual demand and an estimate of possible post discharge referrals from other sources	Burn service estimate
12. OP clinic names	British Burn Association, NSW ACI	Provides an estimate of usual demand	Burn service estimate

	Example Reference	Rationale	Expected data source
13. Telehealth OP follow up	NSW ACI, British Burn Association	Provides an estimate of usual demand; measures uptake of new technology and patient focused care	Burn service estimate
Ward and hospital infrastructure			
14. Integrated with major trauma network	British BurnAssociation	Identifies key organizational supports and inter-dependencies	Survey respondent
15. Ward co-located with critical care	British BurnAssociation	Describes key burn service clinical infrastructure	Survey respondent
16. Designated critical care beds	British BurnAssociation	Describes key burn service clinical infrastructure, organizational supports and inter-dependencies	Survey respondent
17. Formal joint care in critical care	NSW ACI, British Burn Association	Demonstrates key clinical & organizational relationships	Survey respondent
18. Dedicated ward – usual number of beds	Project terms of reference	Describes key burn service clinical infrastructure	Survey respondent
19. Dedicated ward – flex number of beds	Project terms of reference	Describes key clinical infrastructure; may demonstrate mass incident planning	Survey respondent
20. Ward shared with other specialties	British BurnAssociation	Describes key clinical infrastructure	Survey respondent
21. Differential air pressure control - ward	British Burn Association, European Burns Association	Describes key burn service clinical infrastructure and infection control systems	Survey respondent
22. Ward bed configuration	British Burn Association, European Burns Association	Describes key burn service clinical infrastructure	Survey respondent
23. Differential air pressure control - rooms	British Burn Association, European Burns Association	Describes key burn service clinical infrastructure and infection control systems	Survey respondent
24. Thermally controlled rooms	British Burn Association, European Burns Association	Describes key burn service clinical infrastructure	Survey respondent
25. Hydrotherapy facilities	Baier 2018	Describes key burn service clinical infrastructure	Survey respondent
26. Ward water supply	Baier 2018	Describes burn service infection control systems	Survey respondent
27. Own procedure rooms	European Burns Association	Describes key burn service clinical infrastructure	Survey respondent
28. Own operating theatre	British Burn Association, European Burns Association	Describes key burn service clinical infrastructure	Survey respondent
29. Own therapy rooms	British Burn Association, European Burns Association	Describes key burn service clinical infrastructure	Survey respondent

	Example Reference	Rationale	Expected data source
30. Telehealth – accept referrals, advice to referrers, stores images	NSW ACI, British Burn Association	Describes key clinical infrastructure, system and network support	Survey respondent
31. Rehabilitation facilities	NSW ACI, British Burn Association	Describes key burn service clinical infrastructure	Survey respondent
32. Well located for medical imaging	British BurnAssociation	Describes key burn service clinical infrastructure, organizational supports and inter-dependencies	Survey respondent
33. Well located for main Operating Theatres	NSW ACI< British Burn Association	Describes key burn service clinical infrastructure, organizational supports and inter-dependencies	Survey respondent
34. Surge demand management	NSW ACI,	Demonstrates mass incident planning	Survey respondent
Operating theatre availability			
35. Scheduled in hours operating sessions	NSW ACI, ASPS feedback	Describes key burn service clinical services and organizational supports	Survey respondent
36. Other access for major burn injuries	NSW ACI, ASPS feedback	Describes key burn service clinical services and organizational supports	Survey respondent
37. Access for minor burns surgery	NSW ACI, ASPS feedback	Describes key burn service clinical services and organizational supports	Survey respondent
38. Emergency theatre for major burns	NSW ACI, ASPS feedback	Describes key burn service clinical services and organizational supports	Survey respondent
Model of care			
39. Model of care	NSW ACI, British Burn Association, project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
Inter-related services			
Scar management services			
40. education and advice	NSW ACI, British Burn Association	Describes access to key clinical service	Survey respondent
40. pressure therapy	NSW ACI, British Burn Association	Describes access to key clinical service	Survey respondent
40. splinting	NSW ACI, British Burn Association	Describes access to key clinical service	Survey respondent
40. intra-lesional steroid inject	NSW ACI, British Burn Association	Describes access to key clinical service	Survey respondent
40. cosmetic camouflage	British BurnAssociation	Describes access to key clinical service	Survey respondent
40. medical tattooing	British BurnAssociation	Describes access to key clinical service	Survey respondent
40. laser therapy	British BurnAssociation	Describes access to key clinical service	Survey respondent
40. hair restoration	British BurnAssociation	Describes access to key clinical service	Survey respondent
41. Integrated MD outreach, off-site	NSW ACI, British Burn Association	Describes access to key clinical service	Survey respondent

	Example Reference	Rationale	Expected data source
41. Burn research, development	NSW ACI, British Burn Association	Describes burn service activity and staff resource	Survey respondent
41. Education and prof develop	NSW ACI, British Burn Association	Describes burn service activity and staff resource	Survey respondent
41. Fund EMSB courses	NSW ACI, British Burn Association	Describes burn service activity and staff resource	Survey respondent
41. Psychological support for staff	NSW ACI, British Burn Association	Describes burn service activity and staff resource	Survey respondent
41. Admin & support	British BurnAssociation	Describes burn service activity and staff resource	Survey respondent
41. Data Management	NSW ACI, British Burn Association	Describes burn service activity and staff resource	Survey respondent
41. Mx SJS, TEN patients	British BurnAssociation	Describes access to key clinical service	Survey respondent
42. Integrated A & P pain service	NSW ACI, British Burn Association	Describes access to key clinical service	Survey respondent
42. Acute pain service	NSW ACI, British Burn Association	Describes access to key clinical service	Survey respondent
42. Persistent pain service	NSW ACI, British Burn Association	Describes access to key clinical service	Survey respondent
42. Liaison psychiatry	NSW ACI, British Burn Association	Describes access to key clinical service	Survey respondent
42. Medical illustration / photo	British BurnAssociation	Describes access to key clinical service	Survey respondent
42. Prosthetic service	NSW ACI, British Burn Association	Describes access to key clinical service	Survey respondent
43. Surgical specialties FTE, HC	Project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
44. Surgical trainees, FTE, HC	Project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
45. Junior medical staff FTE, HC	Project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
46. Formal burn surgery training	Project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
47. Surgical experience consistent with level of training	P&RS trainee curriculum	Describes burn service training capability	Survey respondent
47. graft minor burns	P&RS trainee curriculum	Describes burn service training capability	Survey respondent
47. debride and graft major burns	P&RS trainee curriculum	Describes burn service training capability	Survey respondent
47. resuscitate major burns	P&RS trainee curriculum	Describes burn service training capability	Survey respondent
47. escharotomy	P&RS trainee curriculum	Describes burn service training capability	Survey respondent
47. reconstruct major burn	P&RS trainee curriculum	Describes burn service training capability	Survey respondent
48. Other medical appointments to Burn Service	British Burns Association, project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent

	Example Reference	Rationale	Expected data source
49. Burn nurse qualifications, experience	NSW ACI, British Burns Association, project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
50. ICU nurses, burn experience	NSW ACI, British Burns Association, project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
51. Theatre nurses, burn experience, scheduled surgery	NSW ACI, British Burns Association, project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
52. Theatre nurses, burn experience, emergency surgery	NSW ACI, British Burns Association,project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
53. Nurse patient ratios	NSW ACI, British Burns Association, project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
54. Burn service allied health FTE, HC – resp physio, physio, OT, dietetics, psychology, play, SW, speech	NSW ACI, British Burns Association, project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
55. Other allied health FTE, HC – resp physio, physio, OT, dietetics, psychology, play, SW, speech	NSW ACI, British Burns Association, project terms of reference	Describes key burn service clinical services and organizational supports	Survey respondent
56. Workforce – surgeon vacancy	Project terms of reference	Provides indication of current and future workforce availability	Survey respondent
57. Workforce intention -burn surgeon	Project terms of reference	Provides indication of current and future workforce availability	Survey respondent
58. Workforce – nurse vacancy	Project terms of reference	Provides indication of current and future workforce availability	Survey respondent
59. Workforce – allied health vacancy	Project terms of reference	Provides indication of current and future workforce availability	Survey respondent
Policy and procedures			
60. admission policy	NSW ACI, British Burn Association	Describes standardised approach to care	Survey respondent
60. referring service guidelines	NSW ACI, British Burn Association, European Burns Association	Describes standardised approach to care	Survey respondent
60. transfer of patients between services	NSW ACI, British Burn Association	Describes standardised approach to care	Survey respondent
60. inpatient rehabilitation	NSW ACI, British Burn Association	Describes standardised approach to care	Survey respondent
60. discharge guidelines	NSW ACI, British Burn Association	Describes standardised approach to care	Survey respondent
60. end of life guidelines	British BurnAssociation	Describes standardised approach to care	Survey respondent

	Example Reference	Rationale	Expected data source
60. infection control	NSW ACI, British Burn Association	Describes standardised approach to care	Survey respondent
60. major incident	National planning requirement, British Burn Association	Describes standardised approach to care	Survey respondent
60. clinical practice guidelines	NSW ACI, British Burn Association	Describes standardised approach to care	Survey respondent

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