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Evaluation and validation of burn care clinical quality indicators within the Burns Registry of Australia and New Zealand (BRANZ)

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A thesis submitted for the degree of *Master of Surgery*
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4 January 2017

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Abstract

While the treatment of burns has improved over the past 30 years, there has been a simultaneous increase in the interest of defining and measuring quality of care in health. This interest has been driven by clinicians, patients and health administrators in search of better health outcomes and to improve quality of healthcare. Clinical quality registries such as the BRANZ have been developed as a systematic way of monitoring quality of care performance and improving patient outcomes.

The heterogeneous nature of burn injuries due to variation in aetiology, age, co-morbidities, burn size and rapidly evolving treatment options has limited research into the quality of burn care. The BRANZ quality indicators are measurement tools that allow clinicians, authorities and organisations to monitor performance and outcomes quantitatively. Since 2009, data has been collected for 19 quality indicators but there have been no attempts at validating these indicators as measures of burn care quality. This study is a retrospective analysis of the BRANZ indicators related to monitoring of renal function and nutritional support. The quality indicators examined are as follows:

1. Was there a negative change of greater than 30 ml/min/1.73m2 of estimated GFR (eGFR) within 72 hours of admission?

2. For an adult with >20% TBSA and a child with >10% TBSA was enteral or parenteral feeding commenced within 24 hours of injury?

3. If the patient had a length of stay greater than 2 weeks; were they weighed within 3–5 days of admission, and were they weighed weekly during their episode of care?

4. Did the patient lose weight during their episode of care (taken days 3–5)?

The thesis aims to investigate if the quality indicators are functioning as valid and reliable measures of burn care quality and if the indicators have the potential for future benchmarking of burn care. The quality indicators were examined for data completion, burn unit participation and whether the indicators had an association with relevant clinical outcomes as a test of validity. The results demonstrated varied degrees of validity between the quality indicators due to weaknesses and strengths in the study design. Lessons learnt from the findings will help direct and strengthen future validation studies of the BRANZ quality indicators analysed.

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Signature: ……

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Acknowledgements

I would like to acknowledge with gratitude my supervisors A/Prof Belinda Gabbe and Dr Heather Cleland. They provided unwavering support, encouragement and limitless patience. Their excellent guidance and knowledge helped in the research and writing of this thesis. I appreciate the significant effort and time they have contributed and thank them sincerely.

I would also like to acknowledge the Burns Registry of Australia and New Zealand (BRANZ) for not only the data on which my thesis is based but for its significant contribution to improving clinical knowledge and outcomes in burn care. I would like to thank all BRANZ contributors, in particular the BRANZ Steering Committee and the BQIWP, for their dedication to ongoing education and clinical excellence in burn care.

I would like to thank my wife and family for their support during the writing of this thesis.

1. Introduction

Burn injury is a common cause of traumatic emergency department presentations and hospital admissions in Australia.[1] Globally, an estimated 11 million burn injuries are treated at healthcare centres where over 300,000 patients succumb to their injuries.[2] Annually, 1% of the Australian population sustains a burn injury and half of these patients experience sufficient morbidity to affect their independent activities of daily living.[1] Burns are a serious public health issue because of the potential to cause lifelong functional impairment, psychosocial disability and death (1-4% mortality of admissions in burn centres internationally).[2-3] Over the last three decades, considerable progress has been made in high income countries at reducing the rates of burn related morbidity and mortality through a combination of public prevention strategies and advances in the care of burn victims.[3]

A burn is damage to skin and or underlying tissue, commonly caused by exposure to a thermal source (scalding, contact or naked flame) but injury can also occur as a result to exposure to chemical, electrical, friction and radiation sources.[2,4] The integumentary system plays a vital role as a protective barrier and has multiple roles in homeostasis, such as temperature regulation, sensation, excretion of waste and vitamin D synthesis.[4] Most burn injuries occur at home or at work and are frequently unintentional.[2] Scalding injuries are most common in children because of the propensity to spill or pull down containers filled with hot liquid.[1,5] Contact burns are caused by direct skin exposure to hot surfaces such as leg burns from motorcycle exhaust pipes or exposed heating elements.[2] Burns sustained from exposure to chemicals or electrocution occur more commonly at work. These work injuries can be more severe due to the higher concentrations of chemicals and high voltage electrical sources at workplaces.[2,4] Irradiation burns are usually iatrogenic in their nature from radiotherapy for adjuvant cancer treatment.[2]

Burn severity is defined by the percentage of total body surface area (%TBSA) affected and depth of epidermal-dermal involvement.[4] Calculation of %TBSA is can be estimated by using the ‘rule of nines’ (Diagram 1) or more accurately using Lund and Browder’s burn estimation chart (Diagram 2).[4] As a rule, a larger %TBSA, and the closer to the extremes of age of the patient, the greater the treatment challenge and the poorer the prognosis.[6-7]

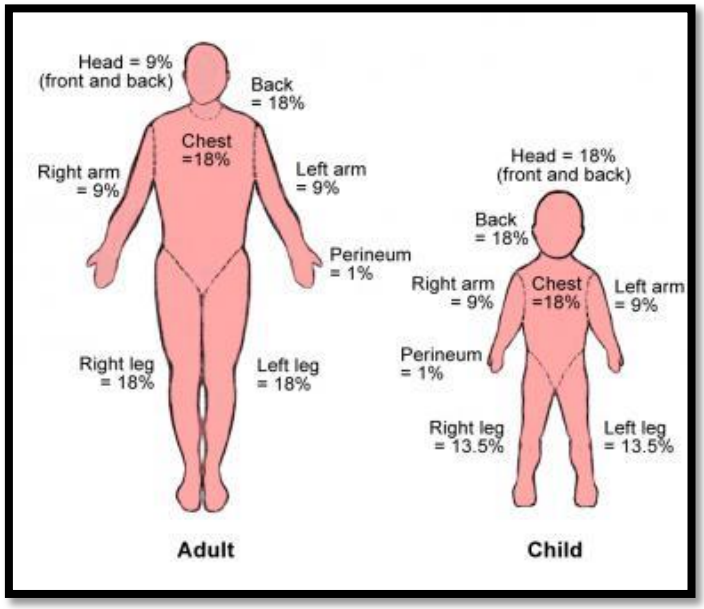

Diagram 1. Rule of Nines[8]

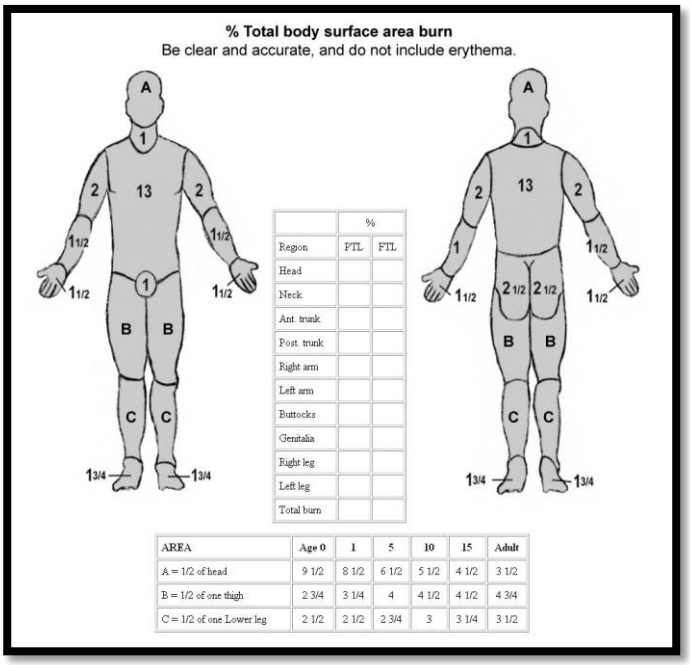

Diagram 2. Lund and Browder Chart[9]

Severe burn injuries (>20% TBSA adults and >10% TBSA in children) trigger complex physiological changes similar to other critically ill trauma patients.[10-11] Patients with large burns sustain an insult that can cause multi-system end organ failure. This requires a multi-disciplinary team approach that is evident in all phases of major burn care; resuscitation, intensive care support, surgical debridement and reconstruction, inpatient care and rehabilitation.[4,10] Management of a major burn patient commonly involves emergency physicians, burn surgeons, dieticians, physiotherapists, occupational therapists, specialist burn care nurses and infectious diseases, anaesthetic and intensive care specialists.[12]

How the burn is managed plays an important role in patient survival and long term outcome.[9] Non-fatal burns are a leading cause of morbidity, including prolonged hospitalisation, disfigurement and disability, often resulting in stigma and difficulties with social integration.[4] Although less than 10% of burn injuries in Australia are greater than 20% TBSA (i.e. severe burn injury), management of major burns is complicated and costly for the health system.[1,13] Optimal management of severely burned persons is enormously expensive, and even after survival is ensured, may require a protracted period of surgical, medical and psychological rehabilitative measures for many years.[1,14] It is estimated that 10% of burn victims are hospitalised and the acute cost of care only represents 20% of the long term financial burden.[14]

The heterogeneous nature of burn injuries due to variation in aetiology, age, co-morbidities, burn size and rapidly evolving treatment options precipitates considerable variation in burn management.[2] There is growing evidence of variation in clinical practice between burn units in Australia and New Zealand (NZ).[15] This variation in burn care makes assessment of quality of burn care difficult and limits research of burn injury management.

Globally, there has been a shift in focus towards better patient-centred care, accountability and transparency within healthcare.[16-17] This has been due to factors such as greater medical awareness among the public leading to demands for better care, keener competition, increasing health care regulation, the rise in medical malpractice litigation, and concern about poor outcomes.[18] Patients, practitioners and healthcare administrators are all stakeholders behind the drive to provide better healthcare.[16,18]

A key step to better treatment outcomes is measurement of the quality of care provided to patients, so that stakeholders may better understand where improvements can be made. Quality care is dependent on the performance of health care practitioners within the limits of the health system they work in.[19-20] Quality of care is defined variously across many health systems. The Institute of Medicine (IOM) in America aptly describes it as "the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge".[21] Monitoring of quality also allows stakeholders to identify the disparities in health between groups of people.[20-22] Quality assessment can be performed when the elements that constitute quality are agreed upon by the assessors.[19]

The IOM recognised that its definition of quality of care was not specific and subsequently identified six characteristics of high quality care. These characteristics need to be taken into account when measuring quality of care[21]:

1) Safe – avoiding injuries to patients from the care that is supposed to help them.
2) Effective – providing services based on scientific knowledge to all who could benefit and refraining from providing services to those not likely to benefit (avoiding underuse and overuse).
3) Patient-centred – providing care that is respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions.
4) Timely – reducing waits and sometimes harmful delays for both those who receive and those who give care.
5) Efficient – avoiding waste, in particular waste of equipment, supplies, ideas, and energy.
6) Equitable – providing care that does not vary in quality because of personal characteristics, such as sex, ethnicity, geographic location, and socioeconomic status.

The IOM characteristics limits the description of quality care as it does not define the stakeholders responsible for health or whether maximally effective or optimally effective care is sought.[19] The individual or societal preferences dictates the optimum. There are aspects of quality that are easy to define and measure, such as technical performance of practitioners, but it can be difficult to assess other more abstract elements for which data is not easily collected for, such as the interpersonal relationship between doctor and patient.[19]

Research into the assessment of quality of care has increased in popularity and depth since the Agency for Healthcare Research and Quality (AHRQ), in America, developed the Healthcare Cost and Utilisation Project (HCUP); a set of health care quality indicators in 1989 based on the IOM quality characteristics.[18] A quality indicator (QI) is defined as 'an agreed upon construct measure that is used to assess quality of care.[21] The HCUP indicators were individual measures of quality that monitored clinical outcomes such as re-admission rates to hospital, with the rationale that a re-admission is related to poor quality of care.[23] Internationally, health care administrators strive to obtain information on health care performance for their planning processes.[16] Evidence suggests that with careful interpretation, information about QI related performance can be used to inform changes designed to lead to improvements in the quality and efficiency of health care services.[24] This can be achieved with quality of care benchmarks that flag potential problems or successes, follow trends over time, and identify disparities across communities, populations, and providers.[16-17]

Subsequently, there have been other organisations that have followed in the AHRQ's lead in creating QIs to measure the quality of care in various specialties.[25] Continued monitoring and assessment of burn care outcomes is essential to achieving improvements in burn management.[25-26] This can be done through the implementation of quality measuring instruments such as QIs. Within the burn specialty, The Australian and New Zealand Burns Association (ANZBA) developed clinical quality indicators that attempt to measure the clinical performance of burn care across the Australia and New Zealand (NZ).[17]

1.1. Background of the Study

Burn care in Australia and NZ is regionalised, with 17 designated burns units across the two countries.[26] Individual burn units in Australia and NZ have historically audited their own performance through local burn registries but the dataset definitions, measures of quality and aims have varied from site to site, thus limiting the potential to identify variations in practice and benchmarking of the quality of burn care.[17] The Australian and New Zealand Burns Association and the Department of Epidemiology and Preventive Medicine of Monash University developed a clinical quality registry which uses 19 specifically developed QIs to measure performance of burn care across the two countries with the aim

of improving quality of care. Clinical quality registries are considered the most accurate method of collecting standardised quality of care data for monitoring health care performance across multiple institutions.[17]

The Burn Registry of Australia and New Zealand (BRANZ) aims to function as a systematic measure of assessing quality of care performance and improving patient outcomes in burn injury through developing standards of care from the data collected.[26] The BRANZ was initially developed as an epidemiological repository in 2004 but was converted to a clinical quality registry in 2009.[17] The BRANZ was developed using the 'Draft Operating Principles and Technical Standards for Australian Clinical Quality Registries' outlined by the Australian Commission on Safety and Quality in Health Care (ACSQHC).[26] Applying the ACSQHC guidelines to the registry, the working party developed 19 clinical quality indicators (QIs) that were embedded within the core data items of the registry. The registry collects burn injury data that measures burn unit performance in relation to the clinical aspects of burn care. The goal of the registry is to utilise this data to develop best practice clinical guidelines, assist in burn care service planning and benchmark quality indicators at an international level.[27] At this stage, there has been no development of acceptable compliance or care standards for any of the QIs.[27] The BRANZ data has been used thus far in summarising certain processes of burn care across the ANZBA sites (outpatient presentations and transfer time to specialist burn centres) but in depth analysis of the QIs is required to achieve the registry's goals of developing clinical benchmark QIs.[20]

1.2. Research Aims and Questions

There are three BRANZ QIs that are related to nutritional support and one that monitors acute kidney injury (AKI). The purpose of this study was to evaluate these four BRANZ QIs. The specific research questions to be answered for each QI were:

i. Does the selected QI have an association with relevant clinical outcomes?

ii. Is the selected QI functioning as a valid measure of burn care quality?

iii. Will the selected QI be appropriate for future benchmarking of burn care?

2. Literature Review

2.1. What is, and how do you assess, a Quality Indicator?

A pioneer in the field of quality assessment, Donabedian highlighted that quality of care is dependent on the interaction between the healthcare system, performance of practitioners, contribution of patients and what is considered the optimum level of care.[19] He developed a framework to examine quality of care based on three categories; 'structure' describes the context in which care is delivered (including hospital buildings), staff, financing, and equipment. 'Process' characterises the prescription and reception of health care between patients and providers within the infrastructure it is provided. 'Outcome' describes the effects of healthcare on the health status of patients and populations.[16,19]

Information about performance in the three categories can be used to improve quality of care because carefully designed structure increases the likelihood of high standard processes and as a result, better outcomes.[19] There must be pre-existing evidence of the inter-relation between structure, process and outcomes, before quality assessment can be performed.[16,22] This approach to quality assessment is essentially determined by the relationship between quality of infrastructure, protocol, competence of personnel and efficiency of operational systems that are aimed at patient centred care.[23] The Donabedian method is a well-established model of health care quality and has been utilised to measure quality through the creation of quality indicators.[26]

Clinical quality indicators are measurement tools that allow clinicians, authorities and organisations to monitor performance of process and outcomes of care quantitatively.[20,22,26] Indicators can be derived from varying levels of evidence supporting the link between a measured process and outcomes of care.[20] This is evident in burn care, where there is a paucity of literature and clinical evidence in some areas of management due to the heterogeneity of burn injury.[26] Interpretation of QIs can be used to inform policy, improve quality of care and monitor performance.[17] The BRANZ QIs were established using Donabedian's Structure-Process-Outcome framework in 2011 (Diagram 3).[16,19]

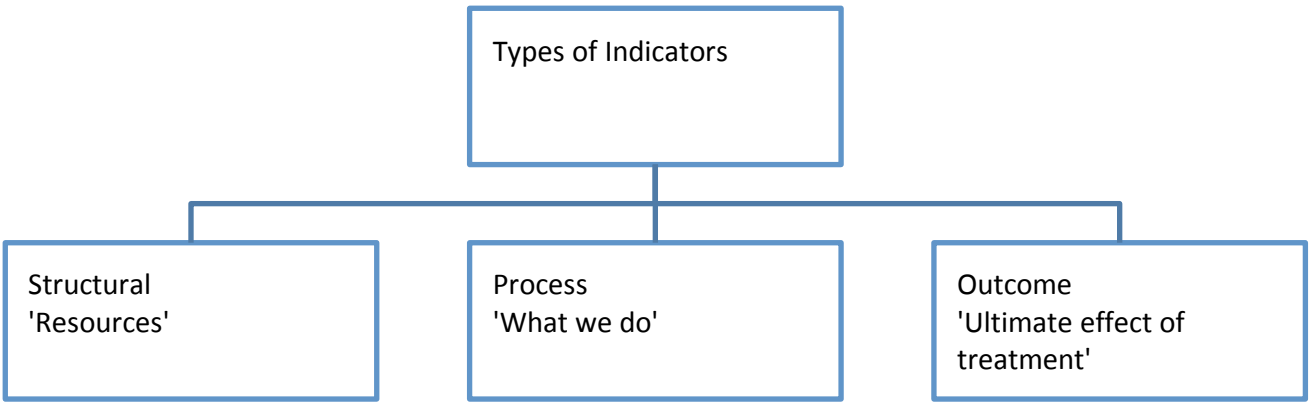

Diagram 3. Donabedian model of quality indicators

The 19 QIs created for BRANZ were also compared to the key characteristics of an ideal QI as outlined by Mainz.[20] For a QI to be effective at differentiating or predicting future performance it must be evidence-based, precise, valid, reliable, accessible and clearly defined.[22,24] The QI validity must demonstrate that the attribute it measures has variations that lead to different health outcomes and permits useful comparisons. The BRANZ QIs concentrate on key areas of burn management to monitor quality of care. The areas can be categorised as[17]:

1) Burns unit resources
2) Infection Surveillance.
3) Burn assessment.
4) Inpatient care.
5) Adverse events
6) Discharge monitoring.

The indicators analysed in this study fall under the categories of burn assessment, inpatient care and adverse events.[17,26] The 'process' QIs measure variables in the process of care based on burn injury concepts that have associations with outcomes that predict quality of care.[16,19-20] The 'outcome' QIs monitor results that arise from management decisions and compare them to other outcomes that are associated with quality of care.[19-20] During the initial QI development, the inter-relation between the key indicator concepts, variables measured and associated outcomes were investigated for each individual indicator.[17] This process was used to demonstrate the 'face validity' of the QIs, the extent to which the QI is theoretically shown to report on the concept it is meant to measure.[26] Unfortunately, performance measures such as the BRANZ QIs cannot rely on face validity but require testing for construct validity based on reliable data to gauge future usability.[23,28]

For a QI to be valid, reliable and consistent data collection is essential in determining the accuracy of the underlying evidence.[30] The QI definition must be precise and specifically measure a single concept.[28] Data completeness describes the fraction of eligible patients that have a valid QI response and is dependent on consistently accurate data collection. Construct validity is the appropriateness of inferences made on the basis of observations the indicator intends to measure.[23,28] In modern validity theory, construct validity is essential to the perceived overall validity of the test. It asks the question, does the QI behave like the theory behind an indicator of that construct should behave? As an example, the construct for a QI measuring early enteral feeding in severely burnt patients will be based on the beneficial effects of early enteral feeding leading to outcomes such as shorter length of stay or decreased rates of in-hospital mortality. As a process, validation involves collecting and analysing data to assess the accuracy of a QI. Numerous statistical tests and measures to assess the validity of quantitative instruments have been performed around the world.[23] These range from associations between two QI scores using non-parametric Spearman correlation to comparing the QI results to multivariate risk-standardised morbidity and mortality outcomes.[23]

2.2. Monitoring for Acute Kidney Injury in burn patients

Severe burn injuries result in a large inflammatory response that causes significant capillary fluid leakage, oedema, hypovolaemic shock and decreased end organ perfusion.[7,31] Poor perfusion to extremely sensitive end organs such as the kidneys can cause renal dysfunction.[32] As a result, critically ill burn patients are at risk of developing an Acute Kidney Injury (AKI) that can have a deleterious impact on the morbidity and mortality (50-70%) of severely burnt patients.[32-33] An AKI is defined as an 'abrupt reduction in glomerular filtration rate (GFR) with failure of the kidneys to regulate volume and electrolyte homeostasis'.[32,34] Although kidney function normalises in the majority of burn patients, AKI is associated with short and long term adverse events.[33,35]

Multiple factors play a part in the development of AKI in the burn victim such as hypovolaemia, cardiac dysfunction, deployment of inflammatory markers, denatured proteins (rhabdomyolysis from electrical burn or full thickness burns) and nephrotoxic drugs.[32-33] Hypovolaemia following thermal injury is due to plasma losses in excess of 4 ml per kilogram of body weight per hour in severe burns and is sufficient to cause a decrease in kidney perfusion alone.[36-37] This, combined with the other factors, act as insults to the

delicate homeostasis of the kidney and can cause AKI in the early and late stages of burn care.[34]

The incidence of AKI can be difficult to assess, in part due to the vague nature of the definition of AKI and also the difficulty in diagnosis of AKI.[36] Prevalence of AKI in patients with burn injury has been shown to range from 0.9% to 64% based on variations in definitions.[37] These variations confound comparison of the existing literature and limit the progress of research into therapeutic interventions for AKI.

Clinical diagnosis of AKI is dependent on a decrease in GFR and this can be deduced from measurements of plasma creatinine and blood urea nitrogen levels, urine output, urine microscopy and chemistry. Plasma creatinine is freely filtered across the kidney (glomerular apparatus) and is not reabsorbed, this makes it a good biomarker of GFR because a reduction in renal function will equate to a rise in plasma creatinine.[32,39] Urine output (UO) is an unreliable parameter because it reflects the difference between GFR and tubular reabsorption and not GFR in isolation.[32,38] As a result, severe AKI can occur without alterations in urine output. Urine microscopy and chemistry is useful in supporting and specifying the aetiology of AKI. Levels of urinary sediment or sodium and the presence of casts (epithelial, hyaline or pigmented) can differentiate between pre-renal (myoglobinuria) and intrinsic renal injuries (acute tubular necrosis).[32]

A standardised classification of AKI, called the “RIFLE” criteria, was developed by the International Acute Dialysis Quality Initiative (ADQI) group in 2004.[34,36] This classification system categorises a reduction in GFR or urine output as three increasing levels of renal insufficiency (Risk, Injury, Failure) and two outcome categories (Loss and End-stage renal disease (ESRD)). The RIFLE criteria have previously been validated in burn injuries where worsening renal function correspond with increasing mortality.[36-37,40]

RIFLE classification

Stages	GFR criteria	Urine output criteria
Risk	Serum creatinine increased by 1.5-2 times baseline or GFR decreased >25%	UO < 0.5ml/kg/hr for less than 6 hours
Injury	Serum creatinine increased by 2-3 times baseline or GFR decreased >50%	UO < 0.5ml/kg/hr for more than 12 hours
Failure	Serum creatinine increased by >3 times baseline or >4 mg/dL or GFR decreased 75%	UO < 0.3ml/kg/hr for 24 hours or Anuria for 12 hours
Loss	Persistent acute renal failure: complete loss of kidney function >4 weeks (requiring dialysis)	
ESRD	Complete loss of kidney function >3 months (requiring dialysis)	

Diagram 4. RIFLE Classification

In 2007, a modification of the RIFLE classification, the Acute Kidney Injury Network (AKIN) staging of AKI was developed to clarify the definition of renal disease and make it more applicable to the clinical setting.[38] The AKIN classification adds specifications to the definition of AKI by describing it as 'an abrupt (within 48 hours) reduction of renal function currently defined as an absolute increase in serum creatinine of more than or equal to 0.3mg/dL, a percentage increase in serum creatinine of more than or equal to 50% (1.5 times from baseline), or a reduction in UO (less than 0.5ml/kg per hour for more than 6 hours)'. There are three stages to the AKIN classification[32,38]:

AKIN Classification

Stage	Serum creatinine criteria (within 48 hours)	Urine output criteria
1	Increase in serum creatinine ≥0.03 mg/dl or increase to ≥1.5–1.9 times baseline	<0.5 ml/kg/hr for >6 hr
2	Increase in serum creatinine to 2.0–2.9 times baseline	<0.5ml/kg/hr for >12 hr
3	Increase in serum creatinine to ≥3 times baseline or serum creatinine ≥4.0mg/dl with an acute increase of at least 0.5mg/dl or initiation of RRT	<0.3ml/kg/hr for >24hr or anuria for >12 hr

Diagram 5. AKIN Classification

The AKIN classification has been shown to be more sensitive at identifying AKI due to the inclusion of the 48 hour time period and a smaller absolute increase in serum creatinine when compared to the RIFLE criteria.[37-38] Although the AKIN modification is more sensitive, it does not improve on the ability of the RIFLE classification in predicting in hospital mortality.[37] For both AKI diagnosis classifications, a proportional mortality increase with increasing AKI severity has been reported.[37] A downside to the RIFLE and AKIN classification is that calculation of a creatinine increase from baseline to peak value and a decreased weight-adjusted urine output over rolling 6 h time periods at the bedside is necessary.[38] Calculating creatinine increases for each hospitalised patient every day is time consuming and costly for the health system.

The treatment of AKI is not clearly defined despite years of research into the pathogenesis of AKI in burns.[32-33,35] The best approach to treatment of AKI is early diagnosis, rapid treatment of the underlying cause and avoiding additional iatrogenic haemodynamic or nephrotoxic injury.[33,35] If conservative management fails, supportive treatment through optimisation of fluid balance, treating acid-base or electrolyte imbalances, adjusting medication doses and renal replacement therapy (haemodialysis or haemofiltration) can be employed in an attempt to reverse AKI.

Currently, the RIFLE and AKIN criteria are the best validated diagnostic classification systems available and GFR measurements based on serum creatinine are best practice methods.[37] However, there are new biomarkers and criteria being developed such as the Neutrophil Gelatinase-associated Lipocalin test or measurement of Cystatin C, that may be more sensitive and specific in the future at detecting AKI.[32,38]

The QI used to monitor renal function in the BRANZ is an outcome indicator: Was there a negative change of greater than 30ml/min/1.73m^2 of estimated GFR (eGFR) within 72 hours of admission? This QI was designed to measure early signs of AKI based on clinical expert consensus during the development of the indicators.[17] Measuring GFR directly is the most accurate way to detect changes in renal function but it is complicated, requires experienced personnel and is used mainly in research settings or transplant centres. The QI uses eGFR rather than GFR as a measure of renal function because eGFR is a calculation from serum creatinine based on age and sex using predictive equations without the need to factor in the weight of the patient.[41] Since 2005, all Australian pathology laboratories have been recommended to automatically report on eGFR if a serum creatinine is ordered.[41] A normal eGFR in a healthy adult is 140ml/min/1.73m^2 but is conventionally reported as >90ml/min/1.73m^2.[41] The QI concept hypothesises that a patient with a documented drop of more than 30ml/min/1.73m^2 in eGFR is at risk of developing AKI. The standardised body surface area of 1.73m^2 is used to normalize the variables for the average 70kg male based on a study in the 1920s. How completely this QI is populated in the BRANZ and the relationship with other key outcomes is not known, and requires further evaluation.

2.3. Management of nutritional support in burn injury

Nutritional support is a vital aspect of burn management that impacts the acute and long term outcomes of the burn victim.[10-11,42] Thermal injury causes an extended hyper-metabolic and catabolic response, which is proportional to the severity (depth and size) of the burn.[11,42] This large oxidative stress is demonstrated by an increase in serum corticosteroid levels, catecholamines and inflammatory cytokines that affects the normal function of the heart, liver, gastrointestinal tract, kidneys, muscle and bone.[11] The overall metabolic effect from increased insulin resistance, gluconeogenesis, energy consumption, lipolysis and proteolysis is that of a catabolic trend which can lead to slower wound healing, skin graft failure, an increase in wound infection, morbidity and mortality.[10-11,42]

Detrimental catabolic effects of the hyper-metabolic response have been documented to persist for a minimum of nine months to a maximum of three years after initial burn injury in a paediatric study.[10] Prolonged hyper-catabolism manifests as deranged immune function, temporary growth retardation in children, osteoporotic changes and potentially fatal cachexia (weight loss of >40% of admission weight) in paediatric and adult patients.[42] Over the decades, varied strategies to combat this complex injury response have been employed by members of the burn team. These strategies can be separated into pharmacological interventions (tight insulin control, beta blockade (propranolol) and anabolic agents such as oxandrolone), non-pharmacological means (early excision of burn, thermoregulation of environment, adequate provision of calories, protein, micronutrients and supplements via enteral nutrition) and precise nutritional monitoring.[10-11,42-43]

To monitor the quality of nutritional support provided to burn patients in Australia and New Zealand burn units, the BRANZ uses two process and one outcome indicator to measure nutritional support practice.[17] These are[17]:

i. For an adult with >20% TBSA and a child with >10% TBSA was enteral or parenteral feeding commenced within 24 hours of injury? (process)

ii. If the patient had a length of stay greater than 2 weeks; were they weighed within 3–5 days of admission, and were they weighed weekly during their episode of care? (process)

iii. Did the patient lose weight during their episode of care (Weight lost (kg) since initial weight measurement from days 3–5)? (outcome)

The first indicator relates to early enteral or parenteral feeding (EEF), routinely used in the setting of critically ill patients.[44-45] The timing and method of nutrition delivery affects the hyper-metabolic response, decreases incidence of stress ulcers and increases immunoglobulin levels.[44-45] EEF can help to maintain the gastrointestinal immunity via modulation of gastric lymphoid tissue.[45] It has been shown that feeding via a nasogastric or nasojejunal feeding tube decreases rates of paralytic gastrointestinal (GIT) ileus, caused by generalised oedema, reduces the risk of malnutrition and also prevents bacterial translocation due to increased intestinal permeability in the setting of a major burn injury.[42] Bacterial translocation may result in bacteraemia and cause lethal sepsis.[44]

These benefits are evident only when enteric feeding is started early and the literature supports the concept that nutrition support should begin within 24 hours, hence the specific development of the BRANZ QI, “For an adult with >20% TBSA and a child with >10% TBSA was enteral or parenteral feeding commenced within 24 hours of injury?”.[42,45] Parenteral nutrition (PN) is an alternative route of feeding that is included in the QI.[43] It is the administration of nutrition via a special intravenous (IV) catheter into a large vein in the chest or the arm that bypasses the gastrointestinal system.[42-43,46] Existing research on PN in burn injuries has shown that it requires extremely strict blood sugar level monitoring and adherence to the patient’s energy requirements to avoid overfeeding.[42] It is used as an alternative method of feeding only if enteral nutrition fails or is contraindicated.[42]

The second and third indicators relate to measurement of inpatient weight loss. The second indicator is a process indicator which establishes whether weight measurement was performed during the patient’s hospital stay, while the third indicator represents an outcome indicator, used to establish if the patient had an overall weight loss during their hospital stay.[26] Measurement of a patient’s weight at different intervals during their inpatient stay is recommended.[42,45] This allows for the estimated calculation of energy requirements and provision of the correct nutrients to combat the unstable hyper-metabolic response.[25,45,47] Energy requirements are proportional to the severity of the injury and it is as essential to avoid overfeeding as it is to not underfeed a patient. Overfeeding increases morbidity by causing fatty liver infiltration and higher infection rates.[42,45,47] A moderate feeding balance is targeted by measuring energy expenditure using either predictive equations or indirect calorimetry.[48-49] Measuring fluctuations in the body weight of burn patients allows clinicians to monitor the patient’s nutritional status but unfortunately weight is often misleading in burn patients due to initial fluid resuscitation (potential to add 10-20 kg of weight) and ongoing fluid shifts from infection, ventilator support, hypoproteinaemia and hormonal changes.[43] This can result in unreliable estimations of energy requirements and lead to under or overfeeding.[42] Weight measurement can be cumbersome due to the size of the injury, immobility, pain and bulky dressings that can add to the inaccuracy of the total weight measured.

Indirect calorimetry is considered to be the current gold standard for gauging energy requirements in critically ill patients as it accurately measures energy expenditure.[50] It works by measuring respiratory gases (oxygen consumed and carbon dioxide produced) under specific conditions (during rest) to quantify the amount of energy used.[49-50]

Unfortunately, indirect calorimetry is not widely available across all clinical sites as the equipment needed is costly, time consuming and requires specialised training.[42]
Predictive equations, based on multiple regression analysis of dependable calorimetric studies, such as the Toronto equation for adult patients and the Schofield equation for paediatric patients are used to measure resting energy expenditure (REE).[42,51] The Toronto equation (kcal/day) was developed in 1990 as a new formula for calculating the energy requirements of burn patients [-4343 + (10.5 x %TBSA) + (0.23 x caloric intake) + (0.84 x basal metabolic rate (Harris Benedict principle)) + (114 x Temperature) - (4.5 x days after injury)].[42] The Schofield equation, developed in 1985, is a method of estimating the resting energy expenditure based on height and weight, shown to have the lowest mean measured and predicted energy expenditure difference when compared to other paediatric equations.[51] Unlike the historical Curreri formula, which commonly resulted in overfeeding, these predictive equations take into account the fluctuating energy requirements over time and provide moderate feeding aims. [42]

The equations are cost effective, widely used and only require knowledge of the patient's weight, height, TBSA% and age.[10,42,48] Predictive equations are limited by accurate weight measurement and do not take into account concurrent confounders such as infection or end organ dysfunction. Despite their limitations, they are the only other validated alternative to measuring energy expenditure and a useful tool in meeting fluctuating nutritional requirements.[42,48] Monitoring the nutritional status of patients plays a vital role in nutritional support of burn injury and can affect burn care outcomes hence the inclusion of the concept of weight measurement in burn care as a QI for the BRANZ.

The BRANZ nutritional support QIs are well supported by the literature, and were shown to have face validity during development,[17-26] but an in-depth evaluation of their use in the BRANZ and their association with other important outcome measures such as length of stay, infection rates, ileus, pressure sore rates, wound breakdown, healing and mortality, are needed.

2.4. Summary

Currently there is no gold standard on how to measure quality of care but measuring instruments such as, the BRANZ clinical QIs, can provide a systematic framework to measure and report on clinical quality of care.[52] The concepts behind the QIs have been demonstrated to have face validity based on literature and expert consensus. Though for burn clinicians to use inferences from the QI results, the indicators must first be shown to demonstrate construct validity, or the "degree to which a QI measures what it claims to be measuring".[30] In this study construct validity is operationalised by significant associations between the QI construct and hypothesised links to outcomes drawn from the initial face validity.

3. Methodology

3.1. Study design

A retrospective analysis of BRANZ data was conducted using quantitative data from five years of registry collection (July 2009 to June 2014).

3.2. Ethics

The study received Monash University Human Research Ethics Committee (MUHREC) exemption from ethical review (approval number CF13/2839 – 2013001532), and approval from the BRANZ steering committee.

3.3. Setting

The BRANZ is a clinical quality registry developed by ANZBA and the Department of Epidemiology and Preventive Medicine (DEPM), Monash University. The registry monitors quality of burn care through the capture of epidemiological, quality of care and outcome data for adult and paediatric burn patients across Australia and New Zealand.[15] Severe burn injury is treated at 17 specialised burn centres across both countries (Diagram 6).[13,15] These burn units service the combined population of Australia and New Zealand which is 28.8 million people as of December 2016.[53-54] The 17 burn centres admit over 2,500 patients per year.[15] These patients are either directly admitted to the burn centre or referred from other hospitals based on the ANZBA referral criteria.

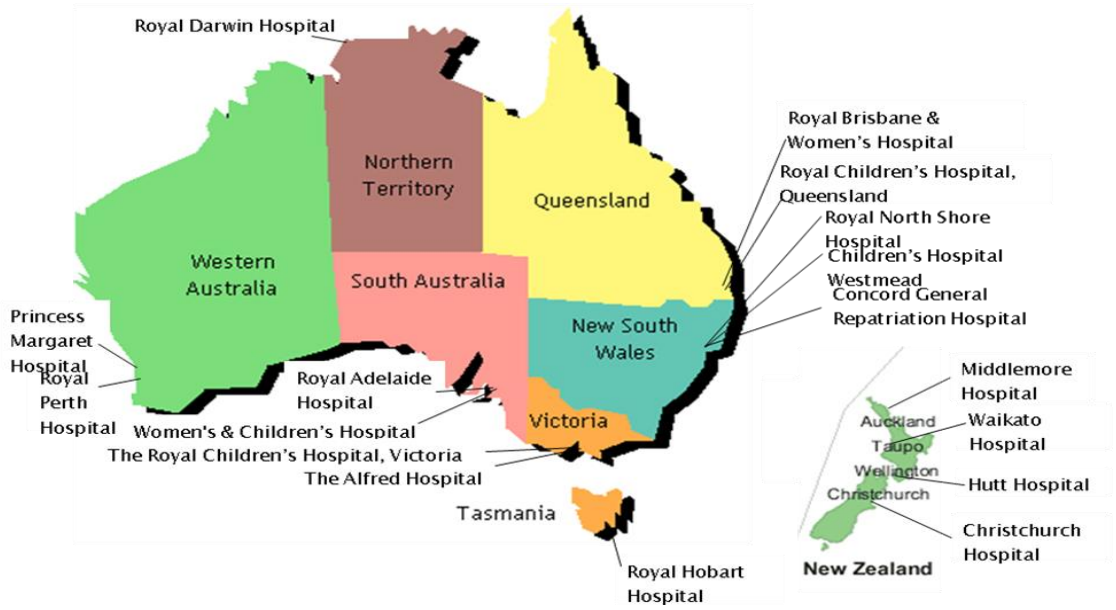

Diagram 6. Burn centres across Australia and New Zealand[15]

The ANZBA referral criteria are clear guidelines that allow clinicians to recognise when a burn injury should be transferred to a specialty burn centre.[15] The criteria is as follows[15]:

- Burns greater than 10% Total Body Surface Area (TBSA)
- Burns greater than 5% TBSA in children
- Full Thickness burns greater than 5% TBSA
- Burns of Special Areas – Face, Hands, Feet, Genitalia, Perineum, Major Joints and circumferential limb or chest burns
- Burns with inhalation injury
- Electrical burns
- Chemical burns
- Burns with pre-existing illness
- Burns associated with major trauma
- Burns at the extremes of age – young children and the elderly.
- Burn injury in pregnant women
- Non-accidental burns

The BRANZ data collection is the responsibility of individual participating burn units.[13,15] As of July 2013, the registry had Institutional Ethics Committee approval for data collection from 16 of the 17 designated ANZBA burn units.[17] Since 2009, 15 burn units have contributed data consistently to the registry, the 16th unit, a paediatric burn centre, has contributed intermittently.[15,17]

Patient data are retrieved via medical records and existing hospital information systems such as, pathology results, and entered into the web-based database by trained data custodians at each participating burn unit. International Classification of Disease version 10, Australian Modification (ICD-10-AM) diagnostic and procedural codes are submitted quarterly to the registry.

3.4. Patient dataset and procedures

De-identified, patient-level data on treatment and outcomes linked with the QIs, with a date of admission from July 2009 to June 2014, were extracted for analysis from the registry. Data extracted from the registry for this study is outlined as below (Diagram 7).

Extracted BRANZ Data	
Patient demographics	
Age	In years
Sex	Male or Female
Hospital	Bi-NBR hospital code
Injury demographics	
Admission details	Time, date, referral source etc.
Injury event	Cause, intent, place and activity at time of injury
Inhalation injury	Intubated patient: Yes or No
TBSA %	Size of burn injury as a percentage
Burn depth	Superficial, Partial thickness (mid and deep dermal), Full thickness
Burn location	Body part/s involved
Treatment and outcomes	
Delays in patient care	Transfer, referral or management delays
Surgical management	Number of operations, Grafting, Dermal substitutes
Enteral/Parenteral feeding QI	Enteral or parenteral feeding administered within 24 hours: Yes or No
Weight Quality indicators	Documented initial weight, weekly weight and weight lost
Monitoring renal function QI	Negative change in eGFR: Yes or No
ICU	Length of stay, ventilated hours
Discharge Outcomes	Discharge disposition, hospital length of stay, in-hospital mortality, cause of death and re-admission rate.

Diagram 7. Data extracted from the BRANZ registry

The presence of inhalation injury was determined from a suggestive history and/or clinical examination during intubation or bronchoscopy. This was recorded as either present or not by clinicians managing the patients.

3.5. Data analysis

The QIs reviewed are relevant to particular patient sub-groups such as by age or burn size. Therefore, analyses were limited to the relevant patient sub-group for each individual indicator being evaluated. The data was checked and cleaned prior to analysis, with sites notified of missing items and provided the opportunity to complete if needed. Variables such as age (numerical age converted into paediatric (0-16 years) and adult (>16 years) cohorts) and ICU hours (re-calculated into days) were re-labelled to ease interpretation of the dataset. Patients over the age of 16 are of legal consenting age and considered an adult within the BRANZ database. The %TBSA variable was re-categorised into 4 easier to interpret categories. Burn cause categories were collapsed to avoid small cell numbers and the potential for statistical disclosure.

3.6. Assessing indicator compliance

Indicator completeness was calculated as the proportion of cases eligible for indicator completion who had a valid response. Where the data collector selected the option of 'not stated or not adequately described', as the indicator was considered incomplete. The completeness rates were calculated overall, and for individual sites. To identify factors associated with indicator incompleteness, eligible cases with valid indicator responses were compared to those where the indicator was incomplete. Chi-square tests were used for categorical variables. For continuous variable showing a normal distribution, an independent t-test was used while a Mann-Whitney U-test was used for continuous variables where the distribution was skewed. Completion rates over time (year of registry operation) were also assessed for each indicator to assess consistency of data collection.

3.7. Validity testing

Construct validation of a QI (process or outcome) aims to establish the relationship a QI has to variables with which it is, theoretically associated with. The validity assessment can be summarised as a question, Are the conceptualised measurement instruments, QIs, reflective of the broader concept from which they were developed? To achieve this, association between the indicators and outcome variables that demonstrate effective burn care was evaluated. The outcome measures of interest were length of ICU stay, ventilation hours, length of hospital stay, in-hospital mortality and rate of readmission to the burn centre.

3.8. Statistical analysis

All analyses were performed using STATA version 12 (StataCorp. College Station, TX). Figures were constructed using Numbers version 4.0.5, Apple Incorporated. To summarise compliance with the process indicators and the distribution of the outcome indicators, overall and by individual site, continuous variables were reported as mean (SD) or median (interquartile range, [IQR]) and categorical variables as count (n) and percentage. Parametric and nonparametric tests were performed where appropriate depending on data distribution. A two-sided p-value of 0.05 was considered to be statistically significant. Independent predictors of mortality and length of hospital stay were identified using multivariable logistic regression analysis performed on the development data set. Logistic regression was used to estimate the risk adjusted odds ratio (reported with a 95% confidence interval) for mortality. The regression model took into account the potential confounding effects of age, %TBSA, inhalational injury and sex. For length of hospital stay, logistic regression was used to estimate the risk adjusted rate of geometric means (reported with a 95% confidence interval). The regression model also took into account the potential confounding effects of age, %TBSA, inhalational injury and sex.

4. Results

4.1. Overall demographics

During the 5-year study period (July 2009 to June 2014), 11,653 patients were registered on the BRANZ registry dataset. Twelve of the 17 Australian and New Zealand burn units that comprise ANZBA contributed data consistently over the study period. Of the 12 sites, three units treated paediatric injuries only, five units treated adult injuries only and four units treated both adult and paediatric burn injuries. Seven of the 12 units admitted over 1,000 patients over the course of the reporting period.

There were 3,017 (27%) paediatric patients, with a mean age of 4.2 years, and 8636 (73%) adult patients, with a mean age of 41 years (Table 1). Patients who were 16 years or older at the time of their admission are classified as adults by BRANZ. The average total body surface area (TBSA) of burn injury in percentage was 6.7% (Table 1). Figure 1 demonstrates the mean TBSA (%) of the individual BRANZ units. The following sections are the results of the retrospective cohort study performed to assess the completeness and validity of the QIs in question.

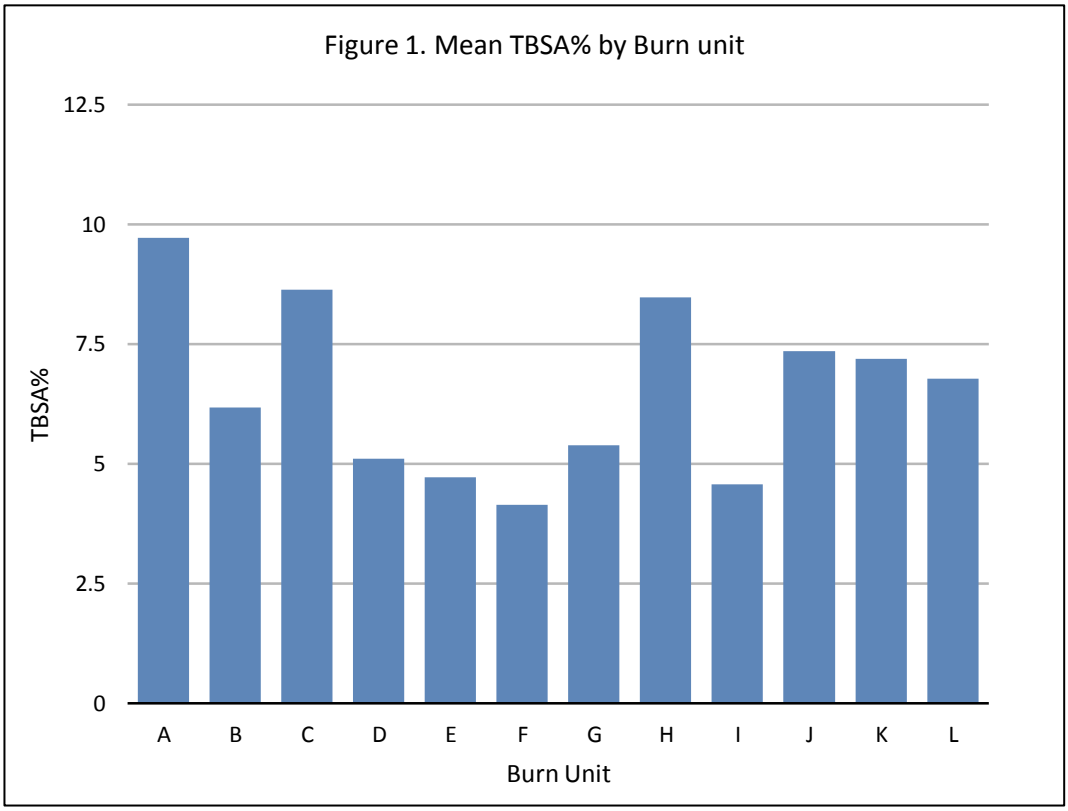

Table 1. BRANZ cohort demographics

Descriptor		**Paediatric (n=3,017)**	**Adult (n=8,636)**
Age	Mean (SD) years	4.2 (4.5)	40.9 (18.3)
Sex	N (%)		
	Male	1,836 (60.9)	6,121 (70.9)
	Female	1,179 (39.0)	2,506 (29.0)
	Intersex/Not stated	2 (0.1)	9 (0.1)
Cause	N (%)		
	Flame	440 (14.6)	3,854 (44.7)
	Scald	1,653 (54.9)	2,406 (27.9)
	Contact	600 (19.9)	1,149 (13.3)
	Friction	222 (7.4)	333 (3.9)
	Chemical	37 (1.2)	475 (5.5)
	Electrical	23 (0.8)	197 (2.29)
	Other	37 (1.2)	200 (2.32)
%TBSA	Mean (SD) %	5.3 (7.7)	7.2 (11.2)
	N (%)		
	<10%	2,620 (86.8)	6,833 (79.1)
	10-19%	299 (9.9)	1,101 (12.8)
	20-49%	78 (2.6)	560 (6.5)
	≥ 50%	20 (0.7)	142 (1.6)

4.2. Quality Indicator: Was there a negative change of >30ml/min/1.73m^2 of estimated glomerular filtration rate (eGFR) within 72 hours of admission?'

4.2.1. Evaluating completeness of data collected for the quality indicator

The registry limits capture of this QI to critically ill patients admitted to the intensive care unit (ICU). Twelve percent (n=1,393) of patients were admitted to ICU; accounting for 175 (13%) paediatric patients and 1,218 (87%) adult patients. Of the patients admitted to ICU, a valid response to the indicator was recorded in 935 cases (67%).

Table 2 summarises the characteristics of patients according to whether the indicator was completed or not. There was a clear bias in the profile of patients where the renal function indicator was complete when compared to patients where it was incomplete (Table 2). The completion rates were higher in adult BRANZ patients, those with burn injury as measured by the %TBSA between 10% to 50%, and where the aetiology of burn injury was direct exposure to flame. The completion rates for this indicator varied widely between the burn units, ranging from 4.5% of ICU admitted (and therefore eligible) patients at Burn Unit C to 96% at Burn Unit A (Figure 2).

Figure 2. Completion rate of eGFR quality indicator

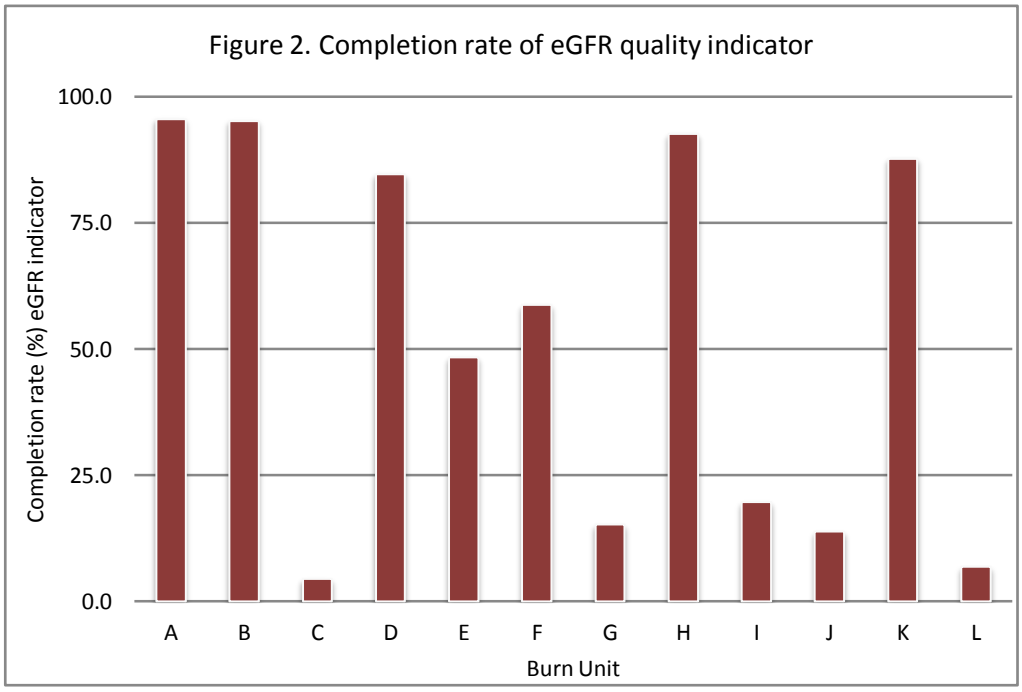

Table 2. Comparison of eligible patients by eGFR indicator completeness

		eGFR indicator complete (n=935)	eGFR indicator incomplete (n=458)	p-value
Age	Mean (SD)	41.5 (19.5)	29.5 (21.0)	<0.001
	N (%)			
	Adult	900 (96.3)	318 (69.4)	<0.001
	Paediatric	35 (3.7)	140 (30.6)	
Sex	N (%)			0.99
	Male	704 (75.3)	345 (75.3)	
	Female	231 (24.7)	113 (24.7)	
TBSA	Median (IQR)	14 (6-27)	16 (6-35)	0.03
	N (%)			
	0-9%	348 (37.2)	173 (37.8)	0.005
	10-19%	236 (25.2)	96 (21.0)	
	20-49%	272 (29.1)	124 (27.1)	
	≥ 50%	79 (8.5)	65 (14.2)	
Cause	N (%)			<0.001
	Flame	754 (80.7)	319 (69.4)	
	Scald	80 (8.6)	71 (15.5)	
	Contact	22 (2.4)	13 (2.8)	
	Friction	10 (1.1)	14 (3.1)	
	Chemical	19 (2.0)	11 (2.4)	
	Electrical	37 (4.0)	21 (4.6)	
	Other	12 (1.3)	10 (2.2)	
Registry year	N (%)			0.03
	2009-10	138 (14.8)	97 (21.2)	
	2010-11	187 (20.0)	91 (19.9)	
	2011-12	229 (24.5)	91 (19.9)	
	2012-13	198 (21.2)	97 (21.2)	
	2013-14	183 (19.6)	82 (17.9)	
Time to admission	Median (IQR) hours	5.3 (2.3-8.5)	4.9 (1.5-12.5)	0.95
Length of hospital stay	Median (IQR) days	15.7 (6.3-31.6)	13.6 (4.9-31.5)	0.14

4.2.2. Comparison of the outcomes for the quality indicator

Of the 935 BRANZ cases where the eGFR indicator was completed, 32 (3.4%) cases were positive, indicating a negative change of >30ml/min/1.73m^2 of estimated glomerular filtration rate (eGFR) within 72 hours of admission. Table 3 provides a summary of the patients admitted to ICU who were either negative or positive for this indicator. The patients who demonstrated a decrease in eGFR (positive result) were younger, and more severely burned (higher %TBSA).

In addition, these patients also stayed in ICU for longer, required longer ventilation times, a longer hospital length of stay and a higher proportion died during their hospital stay, predominantly from multi-system failure (Table 3). There were no unexpected readmissions due to complications in either outcome group.

Patients who experienced a negative change of >30ml/min/1.73m^2 of eGFR within 72 hours of admission (positive eGFR indicator) demonstrated an almost five-fold increase in the unadjusted odds of in-hospital mortality (OR 4.77, 95% CI: 2.05, 11.07). After adjusting for age, sex, the presence of an inhalation injury and %TBSA, the adjusted odds of mortality remained significantly higher (OR 5.26, 95% CI: 1.69, 16.35) compared to patients with a negative eGFR indicator (Table 4).

A positive eGFR indicator was associated with an 80% (ratio of geometric means 1.80, 95% CI: 1.17, 2.78) increase in hospital length of stay compared to patients with a negative eGFR indicator. After adjusting for age, %TBSA, sex, and the presence of an inhalation injury, the length of stay was 38% (ratio of geometric means 1.38, 95% CI: 0.92, 2.05) higher for patients with a positive eGFR but this was not significant (p=0.12) (Table 5).

Table 3. Comparison of patients by eGFR indicator outcomes

		eGFR indicator Yes (n=32)	eGFR indicator No (n=903)	p-value
Age	Mean (SD)	37.1 (25.8)	41.6 (19.3)	0.13
	N (%)			
	Adult	24 (75.0)	876 (97.0)	<0.001
	Paediatric	8 (25.0)	27 (3.0)	
Sex	N (%)			0.43
	Male	26 (81.3)	678 (75.1)	
	Female	6 (18.7)	225 (24.9)	
TBSA	Median (IQR)	31 (15-57)	13 (6-25)	<0.001
	N (%)			
	0-9%	6 (18.8)	342 (37.8)	<0.001
	10-19%	5 (15.6)	231 (25.6)	
	20-49%	9 (28.1)	263 (29.1)	
	≥ 50%	12 (37.5)	67 (7.4)	
Cause*	N (%)			0.40
	Flame	24 (75.0)	730 (80.9)	
	Scald	2 (6.3)	78 (8.6)	
	Contact	0 (0)	22 (2.4)	
	Friction	1 (3.1)	9 (1.0)	
	Chemical	0 (0)	19 (2.1)	
	Electrical	1 (3.1)	36 (4.0)	
	Other	4 (12.5)	8 (0.9)	
In-hospital death	N (%)			<0.001
	No	24 (75.0)	844 (93.5)	
	Yes	8 (25.0)	59 (6.5)	
ICU length of stay	Median (IQR) days	11.0 (3.2-28.6)	2.9 (1.5-8.1)	<0.001
Ventilated time	Median (IQR) hours	98.0 (14.4-408.0)	29.0 (7.2-96.0)	0.02
Length of hospital stay	Median (IQR) days	34.5 (14.9-72.3)	15.5 (6.3-30.3)	0.004

Table 4. Association between eGFR indicator status and mortality: multivariable logistic regression analysis results			
	Odds Ratio	P value	95% confidence interval
eGFR	5.26	0.004	1.7 – 16.3
Age	1.07	<0.001	1.05 – 1.09
%TBSA	3.83	<0.001	2.5 – 5.9
Inhalational injury	1.68	0.1	0.9 – 3.1
Sex	1.96	0.03	1.1 – 3.6

Table 5. Association between eGFR indicator status and length of hospital stay: multivariable logistic regression analysis results			
LOS	Ratio of geometric means	P value	95% confidence interval
eGFR	1.38	0.12	0.92 – 2.05
Age	1.0	0.01	1.0 - 1.08
%TBSA	1.56	<0.001	1.47 – 1.67
Inhalational injury	0.99	0.94	0.86 – 1.14
Sex	1.44	<0.001	1.22 – 1.71

4.3. Quality Indicator: 'Was the patient weighed within 3 to 5 days of admission if their length of stay was greater than 2 weeks?'

4.3.1. Evaluating completeness of data collected for the quality indicator

From July 2009 to June 2014, the hospital length of stay was recorded for 11,641 observations (99.9%). Of the patients with a valid hospital length of stay recorded, 1,988 (17%) stayed in hospital for longer than 2 weeks (a key criterion of the BRANZ weight indicators). Of the 1,988 patients eligible for this indicator, there were 283 paediatric patients and 1,705 adult patients and the indicator was completed for 1,541 (78%) patients. Due to severity of burn injury, 38% of eligible patients were transferred to the ICU for critical care management.

The factors associated with completeness of the indicator are shown in Table 6. There was clear bias (age, sex and %TBSA) in the completeness of the indicator towards older, male and more severely injured patients (Table 6). The completion rates ranged from 12% to 91%, with only one burn unit completing this indicator in less than 58% of cases (Figure 3).

Accurate weight measurement is a vital part of the patient's initial nutritional assessment and is required to calculate the most commonly used algebraic formulas for caloric needs in nutritional support. Of the 661 patients that received either enteral or parenteral feeding, the QI was completed for 515 (78%) patients although this was not statistically significant (p=0.84).

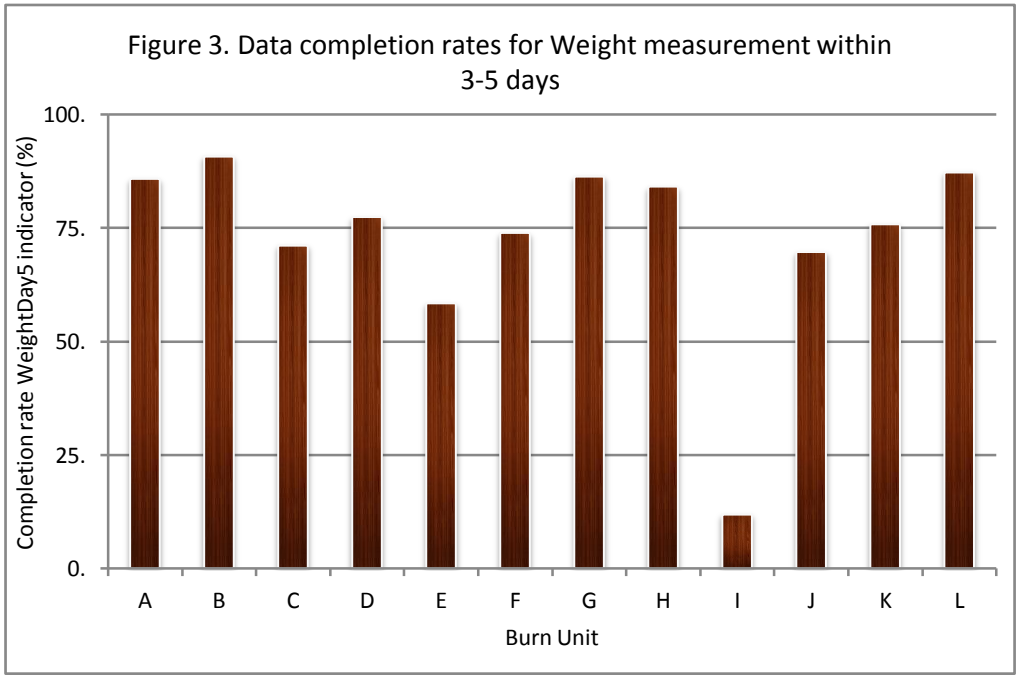

Table 6. Comparison of eligible patients by Weight day 5 indicator completeness

		Indicator complete (n=1,541)	Indictor not complete (n=447)	p-value
Age	Mean (SD)	43.0 (23.1)	36.4 (25.6)	0.001
	N (%)			
	Adult	1,379 (89.5)	326 (72.9)	
	Paediatric	162 (10.5)	121 (27.1)	
Sex	N (%)			0.011
	Male	1,046 (67.9)	286 (63.9)	
	Female	495 (32.1)	159 (35.6) [1]	
TBSA	Median (IQR)	12 (5-23)	9 (4-18)	0.001
	N (%)			
	0-9%	654 (42.4)	232 (51.9)	0.003
	10-19%	408 (26.5)	110 (24.6)	
	20-49%	405 (26.3)	88 (19.7)	
	≥ 50%	74 (4.8)	17 (3.8)	
Cause	N (%)			0.005
	Flame	889 (57.9)	214 (48.4)	
	Scald	362 (23.6)	124 (28.1)	
	Contact	120 (7.8)	44 (10.0)	
	Friction	47 (3.1)	24 (5.4)	
	Chemical	33 (2.2)	15 (3.4)	
	Electrical	42 (2.7)	9 (2.0)	
	Other	43 (2.8)	12 (2.7)	
Registry year	N (%)			0.30
	2009-10	304 (19.7)	75 (16.8)	
	2010-11	350 (22.7)	90 (20.1)	
	2011-12	339 (22.0)	104 (23.3)	
	2012-13	296 (19.2)	93 (20.8)	
	2013-14	252 (16.4)	85 (19.0)	
Patients that received enteral feeding	N (%)	515 (77.9)	146 (22.1)	0.84
Admitted to ICU	N (%)	589 (38.2)	143 (31.9)	0.03
Length of ICU stay	Median (IQR) days	6.7 (2.4-14.5)	7.55 (2.9-17.4)	0.30
Length of hospital stay	Median (IQR) days	22.7 (17.6-35.6)	21.0 (15.7-32.0)	0.0001

[1] There were n = 2 (0.5%) cases where sex was not stated in the 'indicator not complete' group

4.3.2. Comparison of the outcomes for the quality indicator

Of the 1,541 patients with valid weight measurement responses, 681 (44%) acute admissions (median time to admission was 6.5 hours) had their weight recorded within three to five days of burn injury. Table 7 summarises the characteristics of patients that were weighed and those that were not weighed on admission. The key difference between the groups was that weighed patients were younger on average, 72% of paediatric patients compared to 41% of adults patients with complete responses were weighed within the defined time period above (Table 7). Close to 40% (38%, n=589) of the patients with valid weight measurement responses were admitted to ICU but this did not translate to higher rates of an affirmative response as 64% of these ICU admissions were not weighed within the appropriate timeframe. Figure 4 represents the individual BRANZ units' performance for this QI, ranging from 11% to 87% of patients weighed.

The registry collected data on which clinical group instigated patient weighing during each individual admission. The clinicians who most commonly weighed patients were senior burn nurses (65%). There was no difference in the outcome of the QI for patients that were fed via enteral or parenteral routes (45% vs. 55%, p= 0.16).

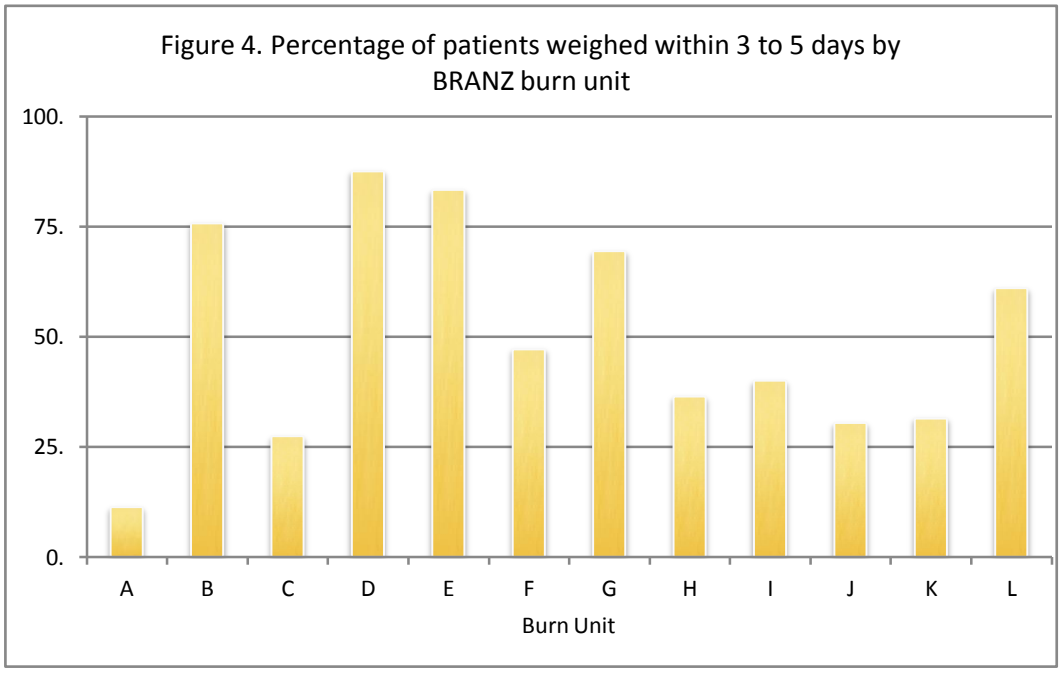

Table 7. Comparison of patients by weight within 3 to 5 days of admission indicator outcomes

		Weighed (n=681)	Not weighed (n=860)	p-value
Age	Mean (SD)	39.1 (23.9)	46.1 (21.9)	0.001
	N (%)			
	Adult	565 (82.9)	814 (94.7)	0.001
	Paediatric	116 (17.1)	46 (5.4)	
Sex	N (%)			0.93
	Male	463 (68.0)	583 (67.8)	
	Female	218 (32)	277 (32.2)	
TBSA	Median (IQR)	12 (5-23)	12 (6-22)	0.5
	N (%)			
	0-9%	297 (43.6)	357 (41.5)	0.62
	10-19%	176 (25.8)	232 (26.9)	
	20-49%	180 (26.4)	225 (26.2)	
	≥ 50%	28 (4.1)	46 (5.4)	
Cause	N (%)			0.21
	Flame	372 (54.9)	517 (60.3)	
	Scald	168 (24.8)	194 (22.6)	
	Contact	60 (8.8)	60 (7.0)	
	Friction	27 (4.0)	20 (2.3)	
	Chemical	15 (2.2)	18 (2.1)	
	Electrical	16 (2.4)	26 (3.0)	
	Other	20 (2.9)	23 (2.7)	
Registry year	N (%)			0.001
	2009-10	182 (26.7)	122 (14.2)	
	2010-11	152 (22.3)	198 (23.0)	
	2011-12	117 (17.2)	222 (25.8)	
	2012-13	106 (15.6)	190 (22.1)	
	2013-14	124 (18.2)	128 (14.9)	
Patients that received enteral feeding	N (%)	232 (45.0)	283 (55.0)	0.161
Admitted to ICU	N (%)	214 (31.5)	375 (43.8)	0.001
Length of ICU stay	Median (IQR) days	6 (2-14.5)	7.1 (2.5-14.5)	0.34
Length of hospital stay	Median (IQR) days	22.1 (17.1-33.8)	22.9 (17.8-36)	0.09
In hospital mortality	N (%)	10 (1.5)	23 (2.7)	0.10

4.4. Quality Indicator: 'Was the patient weighed weekly if their length of stay was greater than 2 weeks?'

4.4.1. Evaluating completeness of data collected for the quality indicator

This BRANZ QI aims to capture the number of patients who were weighed weekly, only when their inpatient stay exceeded 2 weeks. Data from 1,988 eligible patients were collected for this QI. Of these, 1,492 (75%) had a valid response to weekly weight measurement recorded. Table 8 compares the profile of eligible patients according to the completeness of this QI. Patients who had valid responses to the QI were older, sustained larger burn injuries and a higher proportion were flame burns (Table 8).

Almost 80% (79%, n=576), of eligible patients admitted to ICU had valid responses to this QI. Figure 5 demonstrates completion rates for the QI at each participating BRANZ unit. Completion rates were high with the exception of Burn unit I, a paediatric centre with an average admission rate of 200 patients per annum (Figure 5).

Figure 5. Data completion rates (%) for weekly patient weights

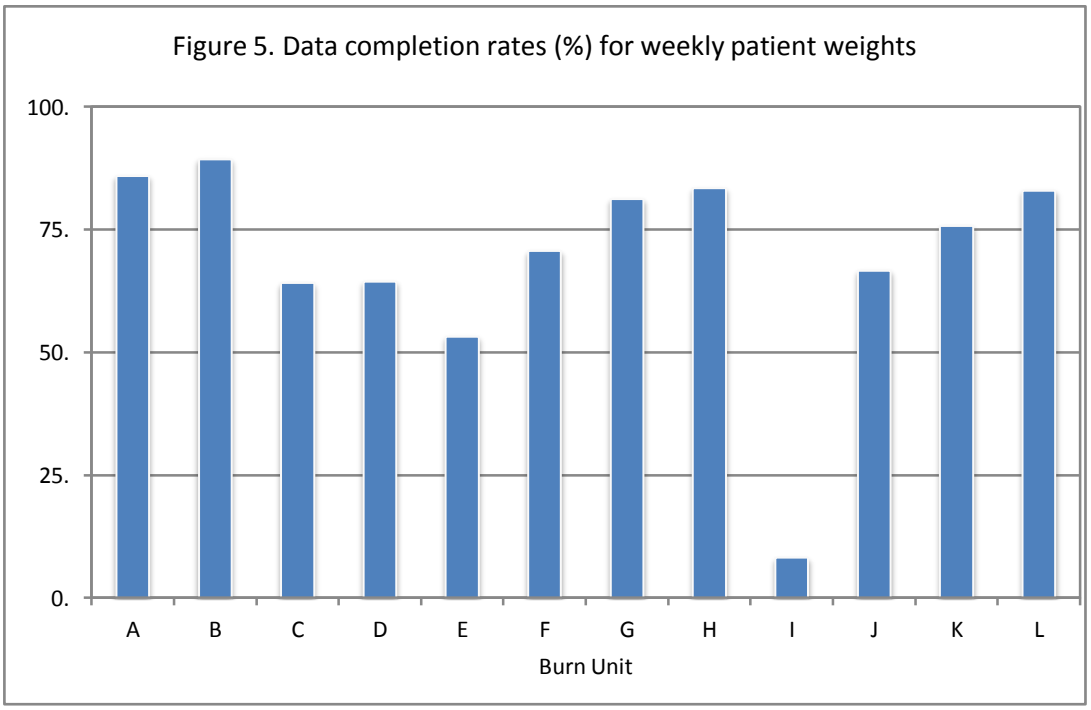

Table 8. Comparison of eligible patients by weight weekly indicator completeness

		Indicator complete (n=1,492)	Indictor not complete (n=496)	p-value
Age	Mean (SD)	43.5 (22.8)	35.6 (25.8)	0.001
	N (%)			
	Adult	1,351 (90.5)	354 (71.4)	
	Paediatric	141 (9.5)	142 (28.6)	
Sex	N (%)			0.01
	Male	1,016 (68.1)	316 (63.7)	
	Female	476 (31.9)	178 (35.9	
TBSA	Median (IQR)	12 (5-22)	9.3 (4-20)	0.0001
	N (%)			
	0-9%	629 (42.2)	257 (51.8)	0.002
	10-19%	400 (26.8)	118 (23.8)	
	20-49%	391 (26.2)	102 (20.6)	
	≥ 50%	72 (4.8)	19 (3.8)	
Cause	N (%)			0.001
	Flame	869 (58.4)	234 (47.7)	
	Scald	345 (23.2)	141 (28.7)	
	Contact	112 (7.5)	52 (10.6)	
	Friction	44 (3.0)	27 (5.5)	
	Chemical	33 (2.2)	15 (3.1)	
	Electrical	41 (2.8)	10 (2.0)	
	Other	43 (2.9)	12 (2.4)	
Registry year	N (%)			0.34
	2009-10	290 (19.4)	89 (17.9)	
	2010-11	343 (23)	97 (19.5)	
	2011-12	331 (22.2)	112 (22.6)	
	2012-13	283 (19)	106 (21.4)	
	2013-14	245 (16.4)	92 (18.6)	
Patients that received enteral feeding	N (%)	499 (75.5)	162 (24.5)	0.91
Admitted to ICU	N (%)	576 (78.7)	156 (21.3)	0.008
Length of ICU stay	Median (IQR) days	6.6 (2.4-14.5)	8 (2.9-17.3)	0.21
Length of hospital stay	Median (IQR) days	22.7 (17.6-35.7)	20.9 (15.8-32.0)	0.001

4.4.2. Comparison of the outcomes for the quality indicator

Drawing from the pool of 1,492 patients with valid responses to this QI, 455 (31%) patients were weighed weekly during their hospital admission. Table 9 summarises the profile of patients that were weighed compared to those that were not weighed at weekly intervals during their inpatient stay. Patients weighed weekly were younger (13% of patients weighed weekly compared to 7.9% of patients not weighed were paediatric cases) and had larger %TBSA burns.

The median length of stay for patients that were weighed weekly was over three weeks (24 days) and 37% of this group of patients were admitted to the ICU. Patients that failed to be weighed spent a comparable median length of stay of 22 days and 40% of patients were admitted to ICU (Table 9). Of the 499 patients that received feeding via enteral or parenteral routes, with completed responses to this QI, 37% of these patients were weighed weekly.

Figure 6 charts the percentage of patients weighed weekly at the individual BRANZ units. The percentage of patients weighed weekly ranged from 70% at Burn unit D to 5% at Burn unit A.

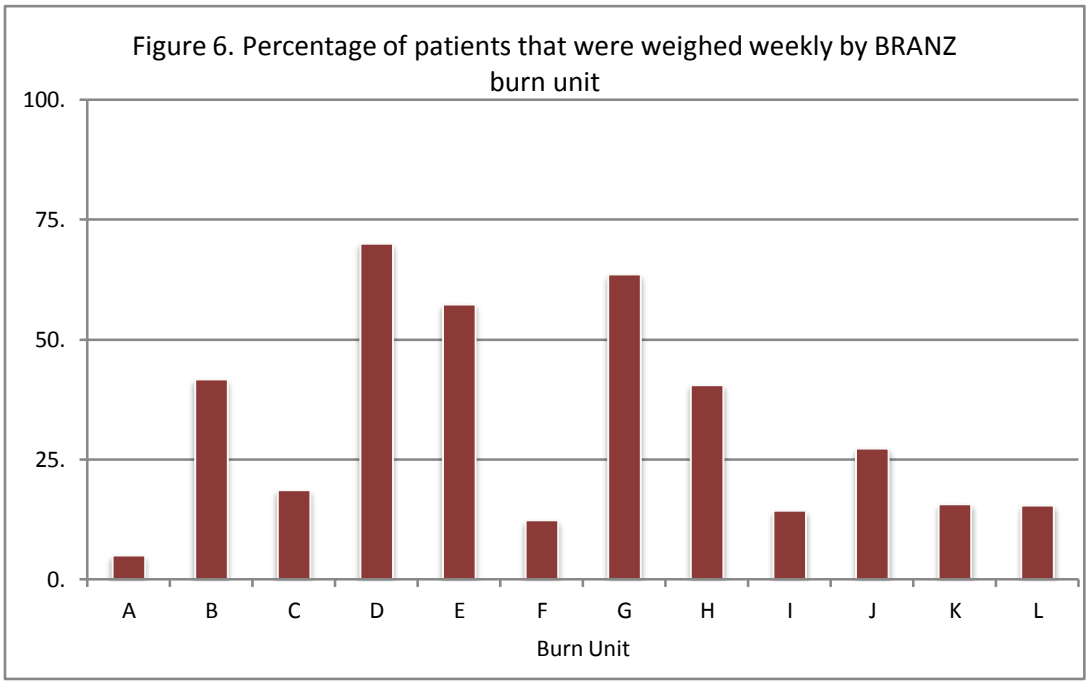

Table 9. Comparison of patients by weighed weekly indicator outcomes

		Weighed weekly (n=455)	Not weighed weekly (n=1,037)	p-value
Age	Mean (SD)	40.2 (23.2)	44.9 (22.5)	<0.001
	N (%)			
	Adult	396 (87.0)	955 (92.1)	0.002
	Paediatric	59 (13.0)	82 (7.9)	
Sex	N (%)			0.46
	Male	316 (69.5)	700 (67.5)	
	Female	139 (30.5)	337 (32.5)	
TBSA	Median (IQR)	15 (6-28)	10 (5-20)	0.001
	N (%)			
	0-9%	164 (36.0)	465 (44.8)	0.001
	10-19%	115 (25.3)	285 (27.5)	
	20-49%	149 (32.8)	242 (23.3)	
	≥ 50%	27 (5.9)	45 (4.3)	
Cause	N (%)			0.22
	Flame	268 (59.2)	601 (58.1)	
	Scald	106 (23.4)	239 (23.1)	
	Contact	33 (7.3)	79 (7.7)	
	Friction	14 (3.1)	30 (2.9)	
	Chemical	10 (2.2)	23 (2.2)	
	Electrical	5 (1.1)	36 (3.5)	
	Other	17 (3.7)	26 (2.5)	
Registry year	N (%)			0.001
	2009-10	120 (26.4)	170 (16.4)	
	2010-11	88 (19.3)	255 (24.6)	
	2011-12	87 (19.1)	244 (23.5)	
	2012-13	71 (15.6)	212 (20.5)	
	2013-14	89 (19.6)	156 (15.0)	
Patients that received enteral feeding	N (%)	187 (37.5)	312 (62.5)	<0.001
Admitted to ICU	N (%)	168 (36.9)	408 (39.5)	0.36
Length of ICU stay	Median (IQR) days	6.6 (2.3-14.8)	6.6 (2.4-14.5)	0.98
Length of hospital stay	Median (IQR) days	24.0 (18-40.8)	22.1 (17.2-33.2)	0.001
In Hospital Mortality	N (%)			
	No	450 (98.9)	1,010 (97.4)	0.07
	N (%) Yes	5 (1.1)	27 (2.6)	

4.5. Quality Indicator: 'If the patient was weighed weekly, did they lose weight during their hospital stay?'

4.5.1. Evaluating completeness of data collected for the quality indicator

The results for this QI were drawn from the pool of 1,988 patients that were eligible for inclusion in the previous QI that measured weight on a weekly basis. There were 501 valid responses recorded as to whether there had been a loss of weight during the patients' inpatient stay. The registry had valid responses from 16% (431) of the adult and 25% (70) of the paediatric patients eligible for this QI. Table 10 compares the differences between the patients with valid responses versus those that were incomplete.

Patients with valid answers had a higher median burn %TBSA (13% vs. 10%). There was no difference in the length of hospital stay between the valid and incomplete cohorts (23% vs. 22%, p=0.04) (Table 10). Figure 7 charts the BRANZ unit completion rates, ranging from 0 to 52% for this QI. More than half of the burn units had completion rates of less than 25%.

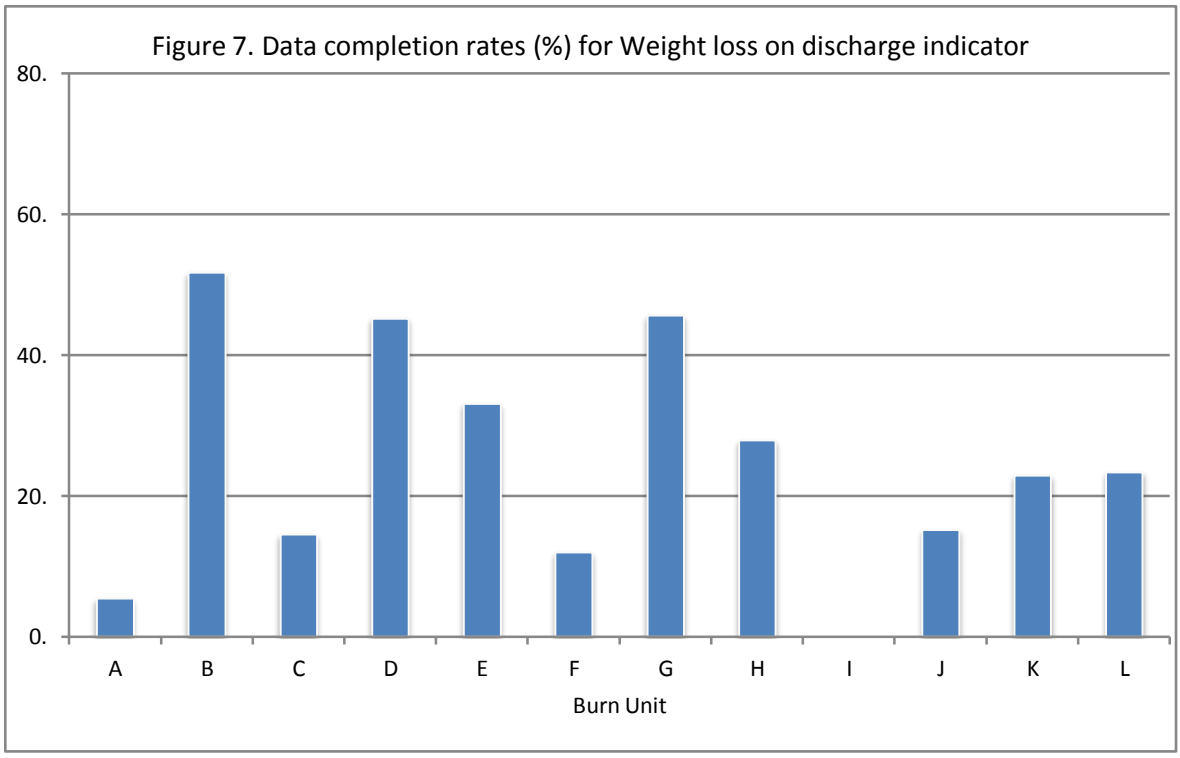

Table 10. Comparison of eligible patients by weight loss on discharge indicator completeness

		Indicator complete (n=501)	Indictor not complete (n=1,487)	p-value
Age	Mean (SD)	39.8 (23.4)	42.1 (23.9)	0.06
	N (%)			
	Adult	431 (86.0)	1,274 (85.7)	
	Paediatric	70 (14.0)	213 (14.3)	
Sex	N (%)			0.58
	Male	342 (68.3)	990 (66.6)	
	Female	159 (31.7)	495 (33.3)	
	Not stated	0	2 (0.1)	
TBSA	Median (IQR)	13 (6-25)	10 (5-20)	0.001
	N (%)			
	0-9%	189 (37.7)	697 (46.9)	0.004
	10-19%	147 (29.3)	371 (24.9)	
	20-49%	142 (28.4)	351 (23.6)	
	≥ 50%	23 (4.6)	68 (4.6)	
Cause	N (%)			0.91
	Flame	286 (57.3)	817 (55.2)	
	Scald	121 (24.3)	365 (24.7)	
	Contact	37 (7.4)	127 (8.6)	
	Friction	19 (3.8)	52 (3.5)	
	Chemical	11 (2.2)	37 (2.5)	
	Electrical	10 (2.0)	41 (2.8)	
	Other	15 (3.0)	40 (2.7)	
Registry year	N (%)			0.001
	2009-10	122 (24.3)	257 (17.3)	
	2010-11	117 (23.3)	323 (21.7)	
	2011-12	91 (18.2)	352 (23.7)	
	2012-13	78 (15.6)	311 (20.9)	
	2013-14	93 (18.6)	244 (16.4)	
Length of hospital stay	Median (IQR) days	23.0 (17.6-36.6)	22.2 (17.6-36.6)	0.04

4.5.2 Comparison of the outcomes for the quality indicator

The premise of the QI is that fluctuations in body weight can be associated with poorer outcomes for burn patients. One hundred and forty-seven of the 501 patients with valid responses experienced a loss of body weight and the differences between the patients are summarised in Table 11. As the burn %TBSA grew larger, the percentage of patients that lost weight increased, the length of stay increased, a higher proportion sustained inhalation injuries and were admitted to the ICU.

Adult patients had a higher rate of weight loss than their paediatric counterparts (31% vs. 19%, p=0.03). Of the 188 patients that received enteral or parenteral feeding and had a valid response to the QI, 72 (38%) patients lost weight (Table 11). The rate of unexpected readmission to hospital due to complications in both groups was zero.

Documented weight loss, over the course of the inpatient stay, was associated with a 45% increase in the unadjusted odds of inpatient mortality (OR 1.45, 95% CI: 0.34, 6.17) but this was not statistically significant (p=0.61). After adjusting for age, sex, the presence of an inhalation injury and %TBSA, the adjusted odds of inpatient mortality were nearly equal (OR 0.97, 95% CI: 0.19, 5.07) (Table 12). The length of hospital stay was demonstrated to be 18% longer in the group that lost weight compared to those that maintained their pre-morbid body weight at the end of the admission (ratio of geometric means 1.18, 95% CI: 1.06, 1.31). Following adjustments for age, %TBSA, sex, and the presence of an inhalation injury, the length of stay was 9.3% (ratio of geometric means 1.09, 95% CI: 0.99, 1.21) longer for patients that lost weight but this was not significant (p=0.08) (Table 13).

Table 11. Comparison of patients by weight loss on discharge indicator outcomes

		Weight lost (n=147)	No weight lost (n=354)	p-value
Age	Mean (SD)	40.7 (22.1)	39.4 (24.0)	0.57
	N (%)			
	Adult	134 (91.2)	297 (83.9)	0.03
	Paediatric	13 (8.8)	57 (16.1)	
Sex	N (%)			0.58
	Male	103 (70.1)	239 (67.5)	
	Female	44 (29.9)	115 (32.5)	
TBSA	Median (IQR)	18 (9-28.8)	11 (4.5-22)	0.001
	N (%)			
	0-9%	40 (27.2)	149 (42.1)	0.001
	10-19%	47 (32.0)	100 (28.3)	
	20-49%	47 (32.0)	95 (26.8)	
	≥ 50%	13 (8.8)	10 (2.8)	
Cause	N (%)			0.21
	Flame	92 (63.0)	194 (55.0)	
	Scald	32 (21.9)	89 (25.2)	
	Contact	10 (6.9)	27 (7.7)	
	Friction	1 (0.7)	18 (5.1)	
	Chemical	4 (2.7)	7 (2.0)	
	Electrical	4 (2.7)	6 (1.7)	
	Other	3 (2.1)	12 (3.4)	
Registry year	N (%)			0.01
	2009-10	27 (18.4)	95 (26.8)	
	2010-11	31 (21.1)	86 (24.3)	
	2011-12	22 (15.0)	69 (19.5)	
	2012-13	31 (21.1)	47 (13.3)	
	2013-14	36 (24.5)	57 (16.1)	
Patients that received enteral feeding	N (%)	72 (48.9)	116 (32.8)	<0.001
Admitted to ICU	N (%)	68 (46.3)	93 (26.3)	<0.001
Inhalation injury	N (%)			
	No	115 (78.2)	310 (87.6)	0.007
	Yes	32 (21.8)	44 (12.4)	
Length of ICU admission	Median (IQR) days	4.5 (2.3-13.6)	7.2 (2.1-15.6)	0.41
Length of hospital stay	Median (IQR) days	26.3 (18.7-45.9)	22.3 (17.2-32.9)	0.001
In hospital mortality	N (%)			0.61
	No	144 (98.0)	349 (98.6)	
	Yes	3 (2.0)	5 (1.4)	

Table 12. Association between weight loss indicator status and mortality: multivariable logistic regression analysis results			
	Odds Ratio	P value	95% confidence interval
Weight loss	0.97	0.98	0.19 – 5.07
Age	1.12	<0.001	1.05 – 1.19
%TBSA	17.43	0.002	2.98 – 101.99
Inhalational injury	1.56	0.65	0.22 – 10.86
Sex	0.97	0.97	0.17 – 5.43

Table 13. Association between weight loss indicator and length of hospital stay: multivariable logistic regression analysis results			
	Ratio of geometric means	P value	95% confidence interval
Weight loss	1.09	0.08	0.99 – 1.21
Age	1.0	0.001	1.0 – 1.01
%TBSA	1.11	<0.001	1.1 – 1.2
Inhalational injury	1.29	<0.001	1.13 – 1.48
Sex	1.02	0.75	0.92 – 1.12

4.6. Quality Indicator: 'Was enteral or parenteral feeding commenced within 24 hours of admission for adult patients with a %TBSA>20 or children with a %TBSA>10?'

4.6.1 Evaluating completeness of data collected for the quality indicator

A valid total body surface area in percentage (%TBSA) was recorded for 11,270 (97%) of the 11,653 patients registered on BRANZ in the 5 year period. Of this total, 1,099 (9.8%) patients were documented to have %TBSA>20 for an adult or a %TBSA>10 for a paediatric case and therefore were eligible for the collection of this indicator. The feeding indicator was completed for 1,034 (94%) of eligible cases, and the completion rates were high at all 12 burn units (Figure 8).

From the patient group with completed responses, there were 664 adult and 370 paediatric patients and 54% of these patients were admitted to the ICU. Patients with completed responses had significantly shorter time to admission, longer hospital admissions and specifically, longer ICU stays. There was no significant difference between the two groups in terms of sex, age or %TBSA (Table 14).

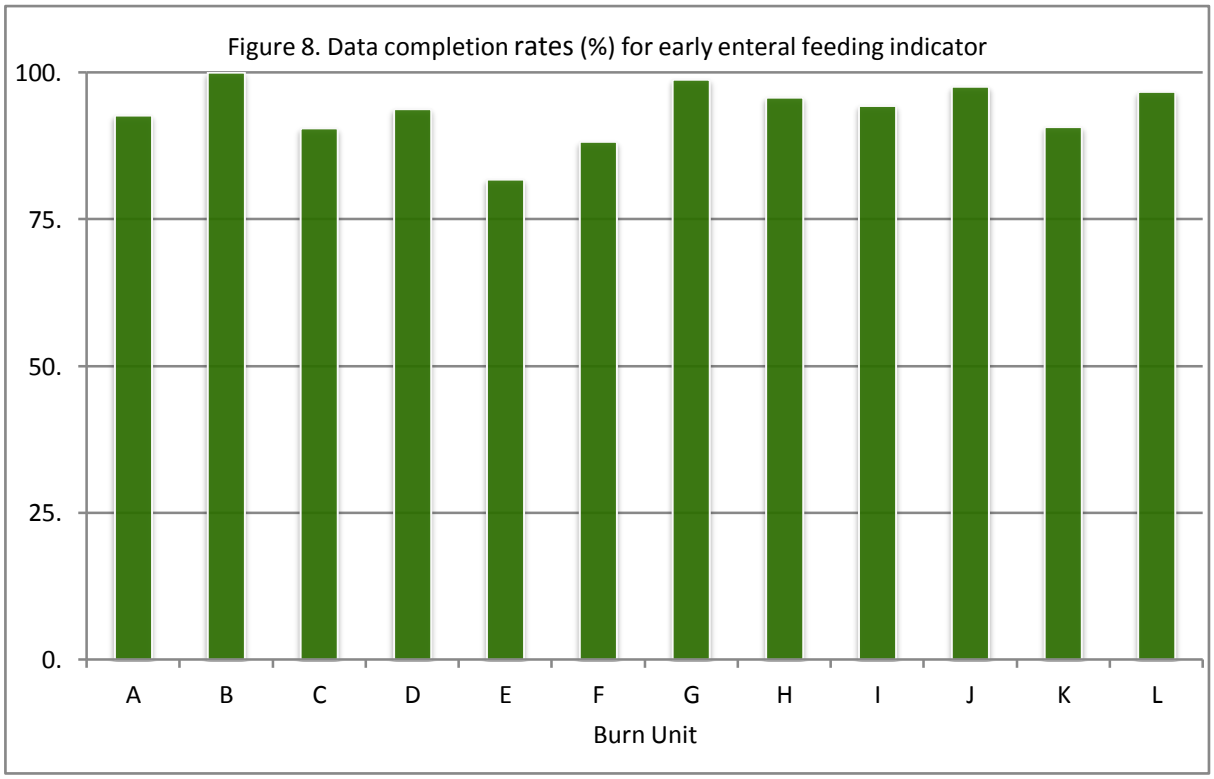

Table 14. Comparison of eligible patients by early enteral feeding indicator completion

		enteral feeding indicator complete (n=1,034)	enteral feeding indicator not complete (n=65)	p-value
Age	Mean (SD)	27.5 (22.6)	27.6 (25.9)	0.95
	N (%)			
	Adult	664 (64.2)	38 (58.5)	0.35
	Paediatric	370 (35.8)	27 (41.5)	
Sex	N (%)			0.9
	Male	741 (71.7)	45 (69.2)	
	Female	292 (28.2)[1]	20 (30.8)	
TBSA	Median (IQR)	25 (18-36.5)	20 (14-24)	0.27
	N (%)			
	10-19%	276 (26.7)	23 (35.4)	
	20-49%	603 (58.3)	35 (53.9)	
	≥ 50%	155 (15)	7 (10.8)	
Cause	N (%)			0.3
	Flame	680 (65.8)	37 (56.9)	
	Scald	302 (29.2)	24 (36.9)	
	Contact	4 (0.4)	1 (1.5)	
	Friction	4 (0.4)	1 (1.5)	
	Chemical	9 (0.9)	0	
	Electrical	13 (1.3)	0	
	Other	21 (2)	2 (3.1)	
Registry year	N (%)			<0.001
	2009-10	180 (17.4)	52 (80.1)	
	2010-11	226 (21.9)	3 (4.6)	
	2011-12	231 (22.3)	1 (1.5)	
	2012-13	228 (22.1)	6 (9.2)	
	2013-14	169 (16.3)	3 (4.6)	
Time to admission	Median (IQR) hours	5.0 (1.7-10.5)	6.7 (3-20.1)	0.02
Admitted to ICU	N (%)	557 (54.0)	29 (45.3)	0.18
Length of ICU admission	Median (IQR) days	6.6 (2-15.6)	2.7 (1-5.5)	0.004
Length of hospital stay	Median (IQR) days	18.7 (8.2-36.1)	12.4 (5.5-19.7)	0.002
In-hospital death	N (%)			0.11
	No	937 (90.6)	55 (84.6)	
	Yes	97 (9.4)	10 (15.4)	

[1] There were n = 1 (0.1%) cases where sex was not stated in the 'indicator complete' group

4.6.2. Comparison of the outcomes for the quality indicator

Of the 1034 patients eligible for this indicator, 660 (64%) received enteral or parenteral feeding within 24 hours of admission. The profile of patients who did and did not receive enteral or parenteral feeding is shown in Table 15. Patients who were eligible for this indicator and did receive enteral or parenteral feeding within 24 hours of admission were more severely injured and of greater clinical acuity according to the %TBSA, need for lengthier ICU admission and hospital length of stay (Table 15). Flame was the most common aetiology for the burn injuries.

The rates of enteral and parenteral feeding were different according to burn unit. There were largely three groups, with two units commencing enteral feeding for more than 75% of patients, most units commencing feeding for approximately 50% to 70% of patients, and two units commencing feeding for less than 40% of patients (Figure 9). A higher proportion of patients assessed by a burn consultant surgeon (within 24 hours) received early enteral or parenteral feeding (78%), compared with other clinician groups. The patients that did not receive early feeding had a significantly higher in-hospital mortality rate, a higher percentage of cause of death from burn shock (71% vs. 29%, p=0.001) and a higher withheld or withdrawn treatment rate (60% vs. 40%, p=0.005). There were no unexpected readmissions due to complications in either group of patients.

The odds of mortality for patients who received early enteral feeding (EEF) were 47% less than patients that did not receive EEF (OR 0.47, 95% CI: 0.35, 0.72). After adjusting for age, sex, the presence of an inhalation injury and %TBSA, the adjusted odds of mortality were significantly lower at 76% (OR 0.27, 95% CI: 0.13, 0.53) (Table 16). Patients that received EEF were associated with a three-fold increase in hospital length of stay (ratio of geometric means 3.36, 95% CI: 2.86, 3.95) when compared to eligible patients that did not receive EEF. After adjusting for age, %TBSA, sex, and the presence of an inhalation injury, the mean length of stay was 3 times longer than the patients that were not fed via enteral feeding within 24 hours (OR 3.44, 95% CI: 2.92, 4.10) (Table 17).

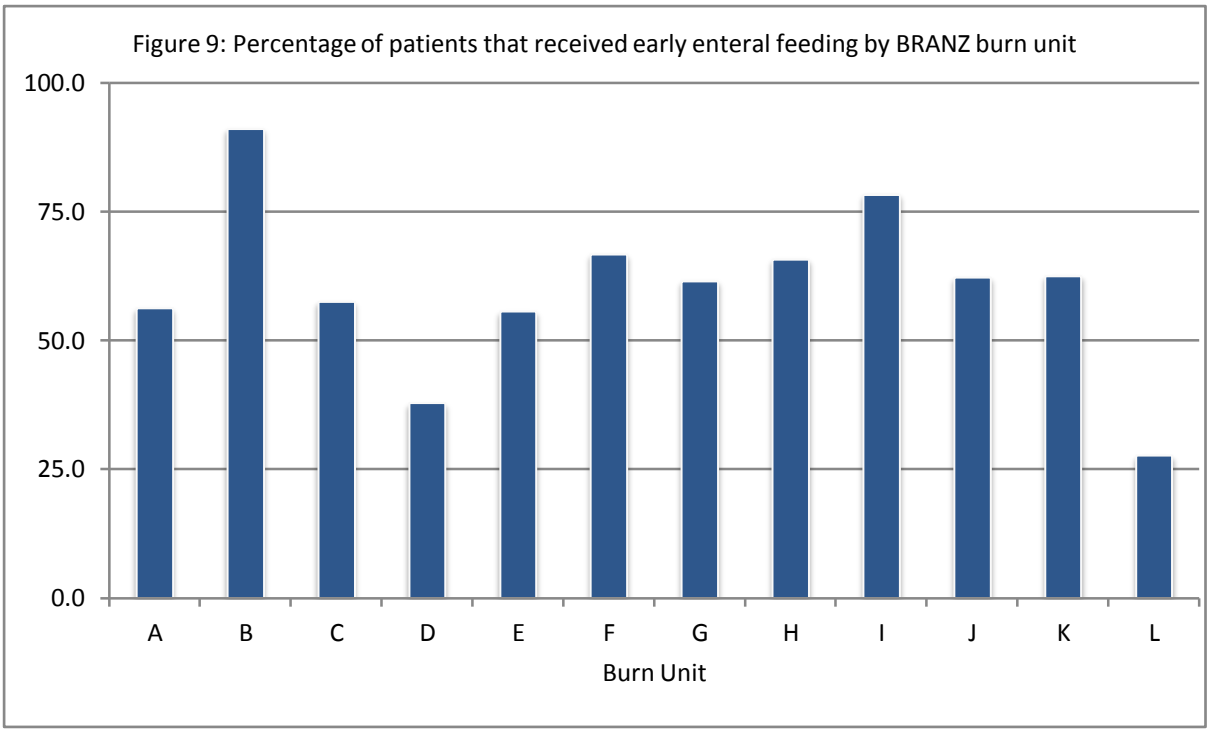
Figure 9: Percentage of patients that received early enteral feeding by BRANZ burn unit
100.0
75.0
50.0
25.0
0.0
A
B
C
D
E
F
G
H
I
J
K
L
Burn Unit

Table 15. Comparison of patients by early enteral/parenteral feeding indicator outcomes

		EEF indicator Yes (n=660)	EEF indicator No (n=374)	p-value
Age	Mean (SD)	27.6 (22.3)	27.1 (23.1)	0.72
	N (%)			
	Adult	428 (64.9)	236 (63.1)	0.57
	Paediatric	232 (35.2)	138 (36.9)	
Sex	N (%)			0.19
	Male	465 (70.5)	276 (73.8)	
	Female	195 (29.6)	97 (25.9)	
TBSA	Median (IQR)	27 (20-40)	21 (13-30)	0.001
	N (%)			
	10-19%	150 (22.7)	126 (33.7)	
	20-49%	404 (61.2)	199 (53.2)	
	≥ 50%	106 (16.1)	49 (13.1)	
Cause	N (%)			0.002
	Flame	457 (69.4)	223 (59.6)	
	Scald	173 (26.2)	129 (34.5)	
	Contact	2 (0.3)	2 (0.5)	
	Friction	1 (0.1)	3 (0.8)	
	Chemical	7 (1.1)	2 (0.5)	
	Electrical	13 (2.0)	0 (0)	
	Other	6 (0.9)	15 (4.0)	
Admitted to ICU	N (%)	452 (68.6)	105 (28.2)	<0.001
Length of ICU admission	Median (IQR) days	9.3 (3.5-18)	1.5 (0.6-2.7)	0.001
Ventilated time	Median (IQR) hours	115 (33.6-276)	9 (0-24)	0.001
Length of hospital stay	Median (IQR) days	24.8 (13.6-50)	10.01 (2.7-19.4)	0.001
In-hospital death	N (%)			0.001
	No	614 (93)	323 (86.4)	
	Yes	46 (7)	51 (13.6)	

Table 16. Association between EEF indicator status and mortality: multivariable logistic regression analysis results			
	Odds ratio	P value	95% confidence interval
EEF	0.27	<0.001	0.13 – 0.53
Age	1.08	<0.001	1.06 – 1.11
%TBSA	132.9	<0.001	47.7 – 370.7
Inhalational injury	2.33	0.01	1.21 – 4.51
Sex	1.82	0.08	0.92 – 3.57

Table 17. Association between EEF indicator status and length of hospital stay: multivariable logistic regression analysis results			
	Ratio of geometric means	P value	95% confidence interval
EEF	3.44	<0.001	2.92 – 4.06
Age	1.01	<0.001	1.0 – 1.01
%TBSA	1.22	0.02	1.04 – 1.44
Inhalational injury	0.70	0.001	0.57 – 0.86
Sex	0.97	0.72	0.82 – 1.15

5. Discussion

The study results establish the state of data completeness, burn unit contribution and validity of the QIs studied. By associating the process and outcome QIs with hypothesised related outcomes, construct validity of the four QIs was evaluated. The findings from this analysis will be discussed for each QI according to the three established research questions:

i. Does the selected QI have an association with relevant clinical outcomes?

ii. Is the selected QI functioning as a valid measure of burn care quality?

iii. Will the selected QI be appropriate for future benchmarking of burn care?

5.1. Monitoring for Acute Kidney Injury in burn patients

The RIFLE or AKIN classifications are standardised definitions with similar prognostic value and have been shown to recognise AKI accurately by measuring either an increase in serum creatinine level or a decrease in urine output.[37,55] Clinical applications of these AKI classifications can be tedious due to the need for bedside calculations of serum creatinine increases from baseline to peak value and close measurement of urine output.[39,56] The eGFR is a readily available measure of renal function validated for diagnosis of chronic kidney disease.[56] Calculation of the eGFR by pathology laboratories is recommended when a serum creatinine level is measured in Australia.[41] Calculating eGFR to monitor for AKI in burn injury is a novel process, the BRANZ QI indicator was examined to evaluate if a decrease in eGFR screens for AKI in a similar manner to the RIFLE or AKIN criteria and whether it is an indicator of quality burn resuscitation.

Overall for this QI, only 67% of eligible patients within the registry had completed responses. Completion rates were highly variable amongst burn units; five of the 12 burn units that contributed had completions rates of less than 20% and three units had completion rates over 90%. Data completion by registry year was low in the first year, peaked during the third year of the study and has since stabilized. The data completion rate was lower than expected for an outcome indicator that monitors changes in a commonly measured biomarker in an ICU setting. Investigation to explain why the data completion rate was low showed that although measuring eGFR is recommended across pathology laboratories, some burn units were not able to collect eGFR data consistently at

the start of the study period. Data completion rates will have to be addressed and will be discussed below.

A positive response to this QI was linked to poorer burn care outcomes as exhibited by the eligible patient cohort (admitted to ICU) that had a decrease in eGFR within 72 hours of admission. This patient cohort sustained larger burn %TBSA, experienced increased ventilation times and in-hospital LOS and a higher mortality rate when compared to their counterparts. Initially, this link to poor outcome was thought to be due to the severity of illness in ICU patients with larger %TBSA but these patients still expressed more than a five-fold increase in the odds of in-hospital mortality after adjustment for age, sex, inhalation injury and %TBSA. After adjusting for the same variables as above, there was also a 38% increase in the length of stay for patients with a drop in eGFR.

These findings demonstrate that a negative change of greater than 30ml/min/1.73m^2 of eGFR within 72 hours of admission, as a measure of AKI in burn injury, has the potential to function as a good predictor of morbidity and mortality. These strong associations only required a small group of patients with valid responses to demonstrate a decline in eGFR and corresponds with the deleterious impact of AKI described in the literature.[37] The BRANZ rate of AKI in burn injury of 3.4% was much lower than the 25% rate found in studies of international populations.[36,38] This difference could be due to the QI's restrictive definition and the use of a different measurement tool. Unlike previous studies that examined the incidence of AKI in all admitted burn patients, the BRANZ QI only collects data on ICU patients, which restricts the size and potentially increases the illness severity of the study population.[38] A higher illness severity in ICU compared to patients on the ward, would theoretically put this study's patients at a higher risk of renal dysfunction and the expected rate of AKI would be higher than the 3.4% that was found.[40] This raises the question of sensitivity and specificity of eGFR as a measurement of AKI when compared to the RIFLE or AKIN classifications. The BRANZ QI measures a set decrease in eGFR that does not allow clinicians to differentiate the severity of AKI whereas the RIFLE classification allows clinicians to stratify AKI into different stages of risk, injury and failure. The AKIN classification has been shown to be more sensitive than RIFLE at identifying a cohort of burn patients with mild AKI who are at greater risk of higher morbidity and mortality rates.[38]

This analysis of BRANZ data has shown that the QI allows clinicians to monitor the

incidence of AKI in ICU, the associated negative impact on morbidity and mortality but it does not allow inference of quality of burn resuscitation or care. Although fluid resuscitation plays a large role in preventing AKI by treating hypovolaemia, other factors such as cardiac dysfunction and sepsis can independently cause renal dysfunction.[58] Therefore, not all AKI in the setting of burn injury can be prevented by quality burn resuscitation. For the QI to demonstrate construct validity as a measure of quality burn care, changes in the definition, collection and evaluation of the QI concept related to burn resuscitation and renal function need to occur. Firstly, to be able to assess quality of care, the QI needs to measure the adequacy of resuscitation against outcomes. High rates of poor outcomes would reflect inadequate resuscitation practice at the corresponding burn unit. The eGFR QI is of uncertain sensitivity and specificity because there is no existing literature to validate the findings of the study. Therefore, a second QI that measures for AKI according to an existing validated classification could be collected concurrently to prevent mono-method bias and to examine for similarity of the associated outcomes for both QIs. For example, a QI that monitors negative changes in eGFR and another that monitors serum creatinine according to the RIFLE or AKIN classifications. Future research could then evaluate both the QIs for significant associations with the suggested fluid resuscitation process indicators and the outcome indicators used in this study to demonstrate negative changes of eGFR as a potentially valid indicator of quality burn care.

Additionally, further research to evaluate if there are other potential processes or outcomes related to burn resuscitation that could be related to the measurement of renal function should be performed. Identifying additional variables to compare the eGFR QI to would increase the validity of the indicator as a measure of quality care. A potential example would be to assess if using processes of burn resuscitation such as fluid resuscitation formulas (modified Parkland's formula) or the use of a Lund-Browder chart to estimate %TBSA are associated with an outcome benefit.[59] If there was an associated benefit proven, these processes could be measured against the eGFR QI.

Finally, clear data definitions and confirmation that all burn units are capable of collecting the same data will improve data completeness and therefore strengthen future research findings. An examination of the burn units that do not perform well for this QI is required to identify and assess the barriers to collection. The BRANZ QI working party have modified the QIs related to monitoring for AKI and begun collecting data. Benchmarking of this QI can begin once the above limitations and suggested changes are made. Further validation of the QI should be carried out using the new criteria. In the future, the QI will be able to be

compared to the AKIN or RIFLE classifications, enabling direct comparisons to studies using these classifications.

5.2. Management of nutritional support in burn injury: Weight measurement

For the QI concept of weight measurement in burn injury, analysis was performed on two QIs, a process and an outcome indicator. Weight measurement is related to the nutritional and fluid status of the burn patient. To estimate how much caloric intake is required for a burn patient, resting energy expenditure equations require accurate body weight measurements for calculation. Inaccurate weights will increase the imprecision of REE calculations and lead to either an over or under estimation of nutritional support.[43] Incorrect nutrition regimes can in turn lead to either malnourishment or obesity, with both states considered to have an increased risk of morbidity and mortality.[45] The hypothesis of the BRANZ QIs is that knowledge of weight fluctuations in burn patients may alter burn care outcomes through the appropriate delivery of nutritional support calculated from REE predictive equations and net weight loss can be used as an outcome to predict poor quality of care.

The process QI, 'If the patient had a length of stay greater than 2 weeks; were they weighed within 3–5 days of admission, and were they weighed weekly during their episode of care?', was examined in two parts. The first part of the QI focused on the validity of weighing patients within 3 to 5 days of admission to measure their baseline dry weight. Weighing data completeness for this section was nearly 80% but only 44% of eligible patients were weighed within 3 to 5 days. The only statistically significant finding was that paediatric patients were more likely to be weighed on admission (72% vs. 41%). This could be related to the culture of routine weight measurement in paediatric burn units recognised by expert consensus or due to the relative ease of weighing children compared to adults because of their smaller stature. Weight recording on admission did not alter outcomes such as length of ICU stay, overall length of stay or in-hospital mortality. Therefore, measuring weight between day 3 and 5 cannot be deduced as a proxy of overall quality of care even though measurement of dry weight assists in calculating more accurate feeding regimes.[43]

The second part of the QI concentrated on the validity of continued weekly weight measurements of burn patients. Data completeness for this section was 75% but again only 31% of eligible patients were weighed weekly. These patients were younger and had larger %TBSA burns but there was no difference in length of stay or mortality. Nine out of the 12 burn units weighed less than 45% of their eligible patients which highlights the difficulties individual burn units experienced weighing patients. The results for this QI failed to confirm the hypothesised associations between initial or regular weight measurement of burn patients and better burn outcomes.

These findings are not surprising: there is a lack of any established evidenced based weight measurement QIs that attempt to directly associate the process of weight measurement with burn outcomes.[25] The literature identifies that although baseline weight should be used in initial fluid resuscitation and estimation of REE, weight accuracy is confounded once resuscitation fluid is administered.[48-49] In fact, the majority of methods used to evaluate nutritional adequacy, such as visceral protein levels and nitrogen balance studies, are confounded by the physiological elements of the hyper-metabolic response.[43] When used collectively and measured regularly, clinicians are able to interpret trends in these various assessment tools to estimate nutritional requirements. Alternatively, burn clinicians can use indirect calorimetry to accurately measure the REE of a patient. The availability of these other assessment tools may help explain the low participation rate of the burn units for this QI because burn units may not rely solely on weight measurement to assess nutritional requirements. Apart from altering burn care outcomes, another hypothetical reason for collection of this QI was to evaluate if burn units that concentrated on weighing long term patients would also pay attention to nutrition and rehabilitation. Collecting data on weight measurement may translate to better outcomes in select populations (elderly patients that require rehabilitation) and it may be appropriate to compare the weight measurement QIs to rehabilitation outcomes in future studies.

The outcome QI, ‘Did the patient lose weight during their episode of care? (Weight lost (kg) since initial weight measurement from days 3–5)’, was dependent on the preceding process QI for eligibility. This meant that data completion for this QI would be affected by the poor participation rates of the previous QI. The rate of data completion was only 25% of eligible patients. Data completion rates by burn units was poor, with the highest rate of valid responses at 51%. The 30% of patients that lost weight during their admission were associated with larger %TBSA increased rate of inhalation burn injury and ICU admission.

Following adjustments for age, %TBSA, sex and inhalation injury, there was no significant difference in ICU length of stay, length of stay or in-hospital mortality. The findings do not reflect the evidence that a loss in total body weight can cause complications related to morbidity and mortality.[31] As a result, the QI has limited construct validity due to its inability to demonstrate an association between weight loss and the related outcomes measured in this analysis. Based on these findings it cannot assess the quality of burn care or be used as a future benchmark at this stage. This is due to a combination of the poor data completion rates, preventing a robust evaluation of the BRANZ study population and to mounting evidence that weight measurement is difficult to accurately measure.

The definition of weight in the BRANZ data dictionary is total body weight, the sum of lean body mass and fat mass. Therefore, this means that the recorded weight loss in this study does not take into account the aforementioned fluid fluctuations but also the amount of weight loss from potential burn skin excision and amputations.[10] Monitoring for lean body mass alone may be a more precise definition of weight and could be recommended to the BRANZ QI development committee.[31] The feasibility of capturing lean body mass through the registry will have to be assessed and explored.

Future evaluation of this QI will also depend on improving the rate of burn unit participation for the process QI that measures the initial and weekly weights and data completion of the outcome QI monitoring total weight lost. Additionally, to address mono-method bias, creation of a similar QI that monitors REE concurrently to the weight measurement QI can be used to validate shared associated outcomes. For example, a QI that measures if indirect calorimetry was used to calculate REE.

5.3. Management of nutritional support in burn injury: Early enteral feeding in severe burns

In the setting of severe burns, EEF has been shown to ameliorate the hyper-metabolic response. The concept behind the QI, ‘For an adult with >20%TBSA and a child with >10%TBSA was enteral or parenteral feeding commenced within 24 hours of injury?’ examines the theoretical hypothesis that if EEF is initiated promptly will impact burn care outcomes.

Data completeness for this QI was high at 94%. All the burn units had greater than 80% data completion. After the first year of data collection, data completion was stable across the next 4 years. Ten of the 12 burn units commenced EEF for 50-70% of eligible patients. The QI criteria was clear, making data collection straightforward. The patients that received EEF were more unwell as suggested by larger %TBSA burns and longer ICU admissions. A positive response to this process QI is associated with a strong mortality benefit, the adjusted odds of mortality for patients that received EEF was 76% lower than patients that did not receive EEF. Patients that received EEF stayed in hospital 3 times longer than their counterparts but within the cohort of patients that did not receive EEF, a higher percentage of patients died from burn shock or had treatment withheld or withdrawn. This group of patients represent a mortality threat to the findings as EEF would have had no effect on their outcome but they were still included in the analysis. This means that the mortality benefit calculated may be an inflated measure. Although this may be the case, the literature supports this finding because EEF has been shown to improve outcomes that contribute to burn mortality.[42,45] The QI demonstrates that it is a valid measure of quality of burn care because it demonstrates that the process of care it measures is associated with a lower rate of mortality.

To improve the validity of this QI, the inclusion criteria for this QI should be examined. Firstly, the cohort of patients that have treatment withheld or withdrawn, who are known to not benefit from EEF, should be excluded from capture of the QI. Future data analysis should focus on the outcomes of severe burn injury survivors only. The second change focuses on the BRANZ definition of early parenteral nutrition, does it mean provision of parenteral nutrition alone or parenteral nutrition with concurrent enteral feeding? The literature describes that administration of parenteral nutrition alone does not provide the gastrointestinal protection enteral feeding offers but administration of parenteral nutrition and concurrent enteral feeding can offer benefits of both routes of feeding.[43] Data collected for this QI combined enteral and parenteral feeding as an amalgamated process. This proved to be an analytical obstacle in discerning the effect on outcomes between the two methods of feeding. The findings suggest that either patients that receive parenteral nutrition are analysed separately to study the impact parenteral nutrition has on morbidity and mortality outcomes or a separate indicator monitors the rate of parenteral nutrition alone versus parenteral nutrition and concurrent enteral feeding.

Future evaluation should also address the mono-method bias of this current study. Similarly, to the previous QIs, comparison of this QI to a second QI that also measures the underlying concept that EEF is beneficial to severely burnt patients will assist in confirming construct validity. For example, an outcome QI that measures the rates of paralytic intestinal ileus or bacteraemia in severely burnt patients. An additional limitation to the analysis of this QI is the inability to differentiate if patients on the lower spectrum of severe burn injury were able to maintain nutritional requirements with or without EEF. A remedy for this limitation would be to collect granular data on caloric intake (Kcal) for each individual patient and subtract patients that did not require EEF from the analysis of the cohort that did not receive EEF. There is potential to use this QI as a process of care benchmark in the future if the construct validity of its association with better outcomes is repeated in re-evaluation studies.

5.4. Limitations

In this analysis of the BRANZ Qis there were a few limitations to the study design. Firstly, not all of the ANZBA burn units contributed to the registry and for some of the QIs the units that did participate had low completion rates. The low completion rates limited the power of the analysis and impacted on the findings. The observational nature of the study meant that only associations could be assessed and any experimental changes that could be performed are only hypothetical suggestions. Another limitation of this analysis is related to the QIs associations to other measures like complications and comorbidities.

Previous attempts to evaluate construct validity of QIs have stressed that an important factor of a measurement tool is how reliable it is. Reliability can be interpreted as the level of consistency the instrument measures the intended variable or outcome. It is not calculable but can be estimated throughout observer reliability or using statistical methods like Test/Re- test or Cronbach's Alpha to measure internal consistency.[23,28,30] Unfortunately, reliability was not analysed in this review of the BRANZ QIs.

6. Conclusion

Overall the four QIs had different rates of data completion and the level of construct validity varied due to multiple reasons. Data completion supports construct validity of a measure by ensuring that the largest possible study population is evaluated. In this study, QIs that had easily interpreted definitions and readily accessible variables (from the

medical records) had better rates of data completion. For example, compliance over the five years improved for an easily recorded process such as EEF but there was no improvement in the collection of weight QIs, potentially due to the clinical challenges of weighing immobile patients. Testing QIs for construct validity is important because it can uncover issues in the definition, scientific evidence and measurement of the concepts that are not perceived during QI development. For example, although construct validity was proven for the EEF QI, none of the QIs are ready to be used as benchmarks for future care due to the issues mentioned above.

Improvements to the evaluation of the QIs for construct validity need to be performed to ensure more accurate analysis of the significant associations with outcomes that are predictors of good quality burn care.[52] This includes comparing the association of two or more QIs that measure a shared concept in the expected direction against affiliated outcomes, as suggested for the eGFR QI. The QIs should be tested for reliability to assess the consistency of the indicator. Future QI examination should also consider the patient's co-morbidities in multivariate logistic regression. This could be performed by mapping the comorbidities to the Charlson Comorbidity index, a score summed from the range of conditions a patient may have, which acts as a predictor of 1-year mortality.

This study establishes that the quest for valid measures of quality requires evaluation of QIs for construct validity. This process of evaluation involves continual appraisal of QI performance against proven associated outcomes and before any before any benchmarking action can be taken the limitations above must be addressed.

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Appendices

Appendix A

MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

2 October 2013

Dear Researchers

Project Number:	**CF13/2839 - 2013001532**
Project Title:	**Validation of Burn Care Clinical Quality Indicators within the ANZBA Bi-National Burns Registry**
Chief Investigator:	**Assoc Prof Belinda Gabbe**

The above application has been reviewed by the Chairs of the Monash University Human Research Ethics Committee (MUHREC) who determined that the proposal satisfies section 5.1.22 of the National Statement on Ethical Conduct in Human Research.

Therefore, the Committee has granted an exemption from ethical review for the research as described in your proposal.

Thank you for your assistance.

[redacted]

Professor Nip Thomson
Chair, MUHREC

cc: Dr Ian Loh

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