

Review

What is the effect of age on wound healing in the acute trauma setting? A scoping review

Upton L

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Abstract

The ability to heal an acute traumatic wound or wounds is a complex matrix of overlapping biological processes impacted by intrinsic and extrinsic human factors. As we age, the body's physiological resilience is compromised and homeostasis becomes difficult to maintain. This scoping review examines the influence of biological ageing and the impact of age-related concerns on wound healing, including frailty, malnutrition, pre-existing medical conditions and clinician practices. Frailty rather than age was seen to have a greater physiological impact on outcome, resilience and healing. Clinician support, education and engagement were fundamental to achieve acute wound healing in the aged population. With an increasing ageing population, specialised knowledge, guidelines and structures to support geriatric care are recommended for best clinical practice.

Introduction

As we age, the body's physiological resilience is compromised and homeostasis becomes increasingly difficult to maintain¹. Immunesenescence describes the remodelling of the immune system that is associated with ageing and can be of detriment for health outcomes¹. This involves the

composition, characteristics and function of cells and systematic inflammation responses¹.

Age is often regarded as the major factor in post-trauma mortality for the geriatric patient²⁻⁵. Studies which focused on frailty over age, as a predictor for poor outcomes, appear to have greater relevance for clinical interpretation of goals of care⁶⁻⁹. The manifestation of frailty is becoming a standardised question when predicting trauma outcomes and futility of aggressive resuscitation and care⁷⁻⁹. Internationally, the definition for geriatric is ≥ 65 years¹⁰.

Normal wound healing is largely dependent on four factors – infective load on the wound, virulence of bacteria, the environment the wound is in, and the patient's physiological reserve¹¹. Predicting normal wound healing relies on the clinician's ability to understand the causes of prolonged healing and failure to heal^{12,13}.

Justification for the review

This review was conducted to establish best practice in caring for the geriatric trauma patient presenting with acute wounds to the acute hospital setting.

The geriatric population are over-represented in poor health outcomes relating to mortality, morbidity and length of stay compared to the younger trauma patient. In Australia, 15% of the population are aged over 65 years, yet they made up 41% of all hospitalisation stays in 2016–2017¹⁰. Delayed time to wound healing or inability to heal contributes to this burden. Burden does not only come as a strain and cost on the health system, but also increases the burden on the patient's ability to achieve a high quality of life while ageing^{1,3,7-9,14}.

Internationally, traumatic injuries are increasing and represent the biggest growth in the geriatric population¹⁴. In a Cochrane review by Ellis et al., there was a consensus for specialised geriatric hospital care through highlighting the immediate and

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increased need in the geriatric patient population¹⁵. In Australia, the Victorian trauma model provides this specialised care in the established trauma system¹⁶. Acknowledgement of the intrinsic and extrinsic factors that predispose the individual's ability to heal need to be comprehensively understood by the clinician. Developing a management plan is also essential to address the underlying factors that delay or reduce the ability to heal¹³. By providing strategies, education and reference points, it is anticipated this vulnerable population can receive preventative and/or early involvement, rather than intervention when complication occurs. Normal barriers to healing are intensified in the older patient population due to tissue health, frailty, malnutrition, susceptibility to greater harm and comorbidities¹⁵.

Method

A scoping literature review was undertaken to examine the question – What is the effect of age on wound healing in the acute trauma wound setting? Compared to the younger adult population, the intention is to identify the physiological differences in geriatric skin, vulnerability to complications, and responses to nursing treatments as all of these impact time to heal and whether complete healing can be achieved. The PICO format was developed to assist clinicians determine these outcomes (Table 1).

Search strategies

Online databases – including MEDLINE, Cochrane, ClinicalKey, CINAHL, ProQuest, Embase, Joanna Briggs Institute (JBI), ScienceDirect – were systematically searched using keywords in OVID (Table 2).

Eligibility criteria

Inclusion and exclusion criteria were developed (Table 2). There were many articles found which related to the keywords from 1998–2010. The focus of these was related to the influx of dressing products and devices on the market at the time; however, articles that focused on dressings or wound products were excluded due to irrelevance to the current review.

Table 1. PICO format

	PICO
P = Patient or population	<ul style="list-style-type: none"> Geriatric/older trauma patient Geriatric defined as >65 years
I = Intervention	<ul style="list-style-type: none"> Nursing assessment of acute trauma wounds Nursing identification of wound healing in acute trauma wounds
C = Comparison	<ul style="list-style-type: none"> Younger adult trauma patient population
O = Outcome	<ul style="list-style-type: none"> Wound healing within the acute physiological phase. Acute healing occurring through the normal phases of wound healing without delay

Study selection

The results of the online data search were imported into reference manager EndNote.

Critical appraisal

Full text articles were appraised using the Joanna Briggs Institute (JBI) levels of effectiveness and meaningfulness¹⁷.

Results

A total of 56 articles were identified for inclusion using the search strategies. A scoping review was conducted according to the preferred reporting items for systematic reviews and meta-analysis (PRISMA) statement (Figure 1)^{18,19}. Extracted themes examine the influence of biological ageing and the impact of age-related concerns on wound healing, including frailty, malnutrition, pre-existing medical conditions and clinician practices (Table 3).

Discussion

Sen et al. introduced the notion of “wound science as an interdisciplinary field” to combat the enormous social and economic impact of wounds and wound healing^{58(p.763)}. They postulate categorising wounds as a separate diagnosis and to be viewed as a specialty rather than grouping under the connected illness such as diabetes for diabetic foot ulcers. They reported an overshadowing and under-financing of wound importance through the current approach. Dyer and Miller supported this notion with the older population, adopting the term dermatoporosis to convey skin fragility in ageing and wanting this to be viewed as a “unique clinical syndrome”^{41(p.13)}. They noted key features of dermatoporosis to include, “atrophic skin with purpura and white pseudoscars on the extremities of elderly patients... and delayed healing” as common presentations^{41(p.13)}.

Trauma in the older person occurs with falls, motor vehicle accidents, recreational incidents, accidents, assaults and self-inflicted harm. Acute traumatic wounds occur from external and internal forces directly related to the mechanism of injury. External injury forces include lacerations, abrasions, penetrations, degloving, amputations and burns. Internal

forces causing wounds include orthopaedic and blunt trauma injuries. Blunt forces resulting in morel-lavallee lesions, ecchymosis or compartment syndrome can cause skin necrosis and delayed wound presentation. The main mechanism of injury of the older trauma patient is falling from a low height; this is closely followed by motor vehicle accidents²⁷. Wounds sustained from these mechanisms are extensive and range from large, open, degloving wounds to simple abrasions. Complex surgical wounds are common with traumatic injury mechanisms and add to the wound complexity of the patient.

Wound healing is a multifaceted matrix of overlapping processes, from inflammation through proliferation to maturation. When re-epithelialisation has successfully been accomplished, a wound can be classified as healed. Epidermal changes occurring with normal ageing result in a flattening of the dermal-epidermal junction, reduced keratinocyte proliferation, and an extended turnover time⁶¹. An imbalance in collagen production and degradation reduces dermal vascularity. Skin is more vulnerable to further injury, due to decreased elastin, increased epidermal atrophy, and reductions in nerve ending⁶⁷. Sgonc and Gruber's review observed that wound healing was delayed with normal ageing rather than it being defective⁶⁰. These delays occur in each stage of wound healing, with the flow-on effect impacting on the next phase. This emphasises the importance of providing the best environment for wound

healing to occur, acknowledging that it may take greater time. Understanding wound healing mechanisms assists in the TIME (tissue debridement, infection or inflammation, moisture balance and edge effect) principle being utilised by clinicians in their wound care³⁵. The goals of care are to improve outcomes on the acute wound, thereby maximising health status and prevention of complication.

Impacts of age-related concerns on wound healing

There are many different impacts of age-related concerns on wound healing in the acute trauma setting, including frailty, malnutrition, pre-existing medical conditions and clinician practices. Some of these will be discussed below.

Inflammation / coagulopathy

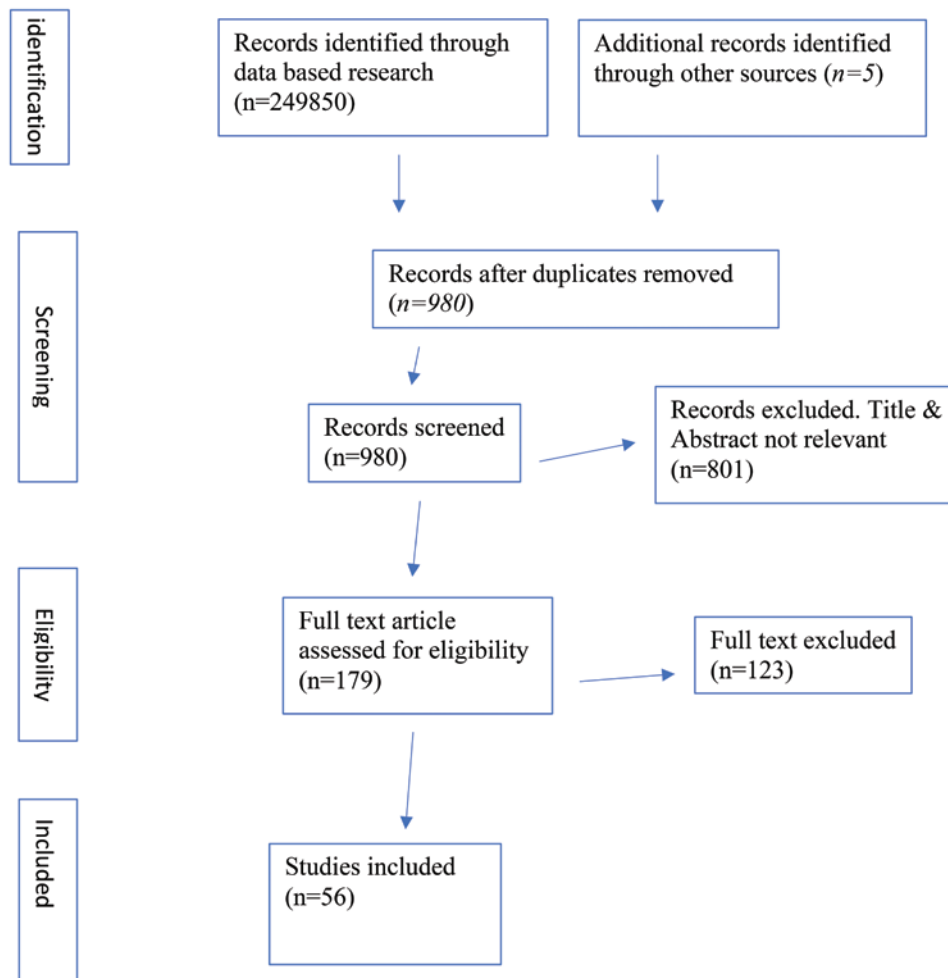
Platelet activation and aggregation results in clot formation during haemostasis and is a key component of the attraction of inflammatory cells to the wound site⁶⁶. Patients taking anticoagulant and or antiplatelet medication have a delay in the initial clotting cascade and an increase in active bleeding. While impacting on this initial stage of healing, blood loss from wounds and injuries can quickly result in life-threatening hypovolemia and shock.

The Trauma Victoria guideline dictates early identification and monitoring of haemoglobin and clotting profiles with treatment to be immediately⁶⁴. Physiologically, acute inflammatory responses can be delayed due to alterations

Table 2. Methodology, keywords and inclusion and exclusion criteria

Online databases	Keywords
<ul style="list-style-type: none"> • MEDLINE • Cochrane • ClinicalKey • CINAHL • ProQuest • Embase • Joanna Briggs Institute (JBI) • ScienceDirect • Intranet hospital setting • Prompt, policy and guideline portal • Government health department 	<ul style="list-style-type: none"> • Aged, geriatric, elderly, older, adult • Frailty • Nursing, nursing care • Wound: wound, acute, traumatic, trauma, care, management, assessment, identification, principles, complications • Skin, epithelisation • Healing, acute phases, acute • Non-healing • Trauma, injury forces • Complications, impact, response • Physiological
Inclusion criteria	Exclusion criteria
<ul style="list-style-type: none"> • Adult participant (>18yrs) • English language • Studies which involved human participants • Studies from 1998–2019 • Original research articles • Studies which examined biological ageing and impact on wound healing, include frailty, malnutrition, pre-existing medical condition and clinician practices 	<ul style="list-style-type: none"> • Abstract only articles • Conference presentations • Studies which examined wound dressings or wound products

Figure 1. PRISMA flow chart



in cytokine production, cell adhesion and migrations; these all occur with ageing²³. A common feature of delayed healing is an extended inflammatory stage³⁵. Mimicking this at a system level, Hazeldine et al.'s systematic review found this same detrimental, sustained inflammatory response in the geriatric trauma patient population¹. It exposed an abnormal response culminated in extended inflammation, decreased immune responses, and resultant delays or failure to return to homeostasis. In addition, Soysal et al.'s systematic review and meta-analysis concluded a direct relationship between higher serum inflammatory levels and frailty⁹. A relationship appears to occur between inflammation and frailty, with increased mortality, morbidity and hospital length of stay outcomes.

Proliferation

Granulation tissue formation is reliant on angiogenesis to be initiated and sustained with an adequate blood supply³⁵. With ageing, a reduction in the capability for angiogenesis and delayed re-vascularisation result in prolonged healing. Greenhalgh described the skin changes prevalent with ageing – including impairment of new vessels and their

perplexity to leak, delayed lymphatic draining and oedema – as major causes of stalled wound healing⁴⁶. In normal healing, the vascular disruption, causing hypoxia, stimulates hypoxia inducible factor and stromal-derived factor, which in turn promotes keratinocyte and fibroblast migration, induce angiogenesis, and stimulating healing⁶⁰. In the aged, this hypoxic reaction appears impaired, therefore impacting on blood vessel formation, and oxygen and nutrient transport to the wound.

Tissue remodelling

The final phase of wound healing is tissue remodelling. During this stage, extracellular matrix inside the granulation tissue matures and increases in strength, resulting in a collagen-rich scar⁶⁵. In the tissue remodelling stage, age appears to impact collagen remodelling and deposits. A diminished blood supply reduces the extracellular matrix and delays tissue approximation. Wounds healed under suboptimal conditions appear to have greater susceptibility to secondary insult of infection and repeated trauma⁶⁰. Bond et al.'s observational study, using healthy volunteer, found shorter maturation time and better scar quality in the older adults when in an optimal

environment²⁶. Sgonc and Gruber hypothesised, “while ageing adversely effects the speed of wound healing during early phases, it may accelerate maturation and improve scar quality under optimal wound care”^{60(p.163)}. These studies rely heavily on optimal wound environments and the ‘healthy’ older patient, identifying that wound healing can occur in this patient population when optimal conditions are achieved.

Healing

The health of the microcirculation that supplies the wound bed is the determinant factor for wound healing²⁴. Noblet et al.’s cohort study, on soft tissue trauma in the aged, could show comparable healing (to younger patients) when identification and optimisation of individual patient challenges are carefully managed⁵⁴. Blass et al.’s randomised controlled trial (RCT) found targeting the microcirculation with antioxidant micronutrients and glutamine achieves greater wound healing in a shorter timeframe²⁵. Demidova-Rice et al. and Greenhalgh note the presence of diabetes as a major contributor to delayed wound healing and failure to heal^{35,46}. Better outcomes can be achieved, with greater clinical awareness, of the existence of delayed healing. Physiologically, in the wound of an otherwise healthy individual with optimal wound bed conditions, healing occurs regardless of age. The presence of pre-existing comorbidities, frailty, malnutrition and vascular disease mean that delayed wound healing and failure to heal can occur. Optimising the health of the patient to enable homeostasis and physiological resilience is therefore a constant clinical challenge in this patient population.

Frailty

A discussion appears in the literature as to whether age alone is a determinant of poor outcomes and delayed healing. Pure statistics report that patients over 65 are at greater risk of mortality and poor outcomes from trauma than younger patients¹⁰. These studies look at a direct comparison between the young adult and the older adult. Other studies reflect the need to question the frail-aged verses the well-aged^{1,3,25,35,60}. Frailty syndrome is broadly considered as decreased physiologic reserve across multiple organ systems leading to an impaired ability to withstand physiological stress. The frail patient is vulnerable to functional decline, deficit accumulation, and biological response delays²⁰. The frail patient’s immune responses, including prolonged inflammation, is a well-documented finding^{9,41,31}.

Ellis et al.’s intervention study identified the geriatric frail patient as requiring multidisciplinary specialised assessment, care planning and intervention¹⁵. Frail patients are at a higher risk for poor outcomes following even minor injury, including postoperative complications, discharge to aged care nursing facilities rather than rehabilitation units or home, and death. The concept of frailty has gained international support as a useful assessment. Currently the search is on to find a validated frailty assessment tool. The Canadian study of health and ageing clinical frailty scale is gaining recognition

as a benchmark tool³¹. Throughout the literature search, ‘frailty’ was prevalent in most articles reviewed from 2015 to current. The Canadian frailty assessment tool was cited in many of these articles.

Pre-existing medical conditions

Pre-existing chronic disease, including heart disease, stroke, cancer, diabetes and chronic lung disease, are jointly accountable for 71% of all mortality globally⁶⁶. Pre-existing conditions predispose patients to traumatic incident, compromise compensatory mechanism, and obstruct recovery. In the trauma setting, Hildebrand et al.³ found supporting evidence of pre-existing conditions causing worse outcomes to comparable patient’s disease free; however, they also found supporting studies to reject pre-existing conditions as a major factor to poor outcomes following trauma. The studies rejecting pre-morbid conditions as a predictor for poor outcome following trauma were mostly single institution and cohort studies. These studies found pre-hospital care and injury severity score to be the greater predictor of mortality in the older trauma patient.

Hashmi et al.’s systematic review and meta-analysis concluded being unable to find consensus with pre-existing medical conditions’ direct impact on poor outcome². Discussion focused on the greater impact of pre-hospital care, the presence of ongoing hypotension, and injury severity score as independent risk factors to poor outcome in the older trauma patient. Hashmi et al.² critiqued these studies that found against pre-morbid conditions as inadequate to correctly provide robust finding for this conclusion. One study concluded mechanism of injury as the biggest predictor for outcome; however, did not report mortality rates based on mechanism of injury².

Brown et al.’s systematic review hesitantly supported the notion of pre-morbid condition as producing poorer outcomes⁴. They discussed the lack of literature and inconsistencies in studies to provide a robust argument to support this notion. The findings of the predictability of disability post-trauma by Gabbe, Harrison, Lyons, Edwards and Cameron⁴³ established comorbidities, over age, as the better predictor of poor recovery. This study noted the limitation of a reliable comorbidity definition and measurement tool. In their prospective cohort state-wide study, their results indicated pre-existing comorbid clinical conditions as fundamentally dictating recovery, and even survival, following major and even minor trauma⁴³.

While the presence of pre-existing medical conditions impacts on health and well-being and are a contributory factor to trauma, there is inconsistency in their independent contribution in poor outcome in the older trauma patient in the literature. A limitation in trauma-based studies is that death and disability constitute a poor outcome and are often the only measures used. Pre-injury function can be difficult to ascertain in order to provide a reliable post-injury comparison in the older population. Post-injury function is

Table 3. Overview of published studies

Author and year	Design	Article source	Extracted themes and relevance to review / inclusion criteria
Adams et al. 2015 ²⁰	Expert opinion	Current Opinion in Critical Care	Geriatric and trauma
Baldwin et al. 2016 ²¹	Randomised controlled trial	Cochrane Database of Systematic Reviews	Supportive interventions for at risk adults. Dietary intake and malnutrition
Beelen et al. 2018 ²²	Randomised controlled trial	Clinical Nutrition	Nutrition in the older adult (protein specific)
Bentov et al. 2014 ²³	Expert opinion. Review	Anesthesiology	Wound repair and ageing. Examining anesthetic management in optimising microcirculation. Examining potential improvements to post-operative wound repair in older adults
Blass et al. 2013 ²⁴	Cross sectional study	Clinical Nutrition	Wound healing in the trauma patient. Micronutrients, malnutrition and oxidative stress
Blass et al. 2012 ²⁵	Randomised controlled trial	Clinical Nutrition	Wound closure in trauma patients. Oral micronutrients shown to shorten time to wound closure. Randomised, double blinded placebo controlled trial
Bond et al. 2008 ²⁶	Observational study	American Society of Plastic Surgery	Maturation, scaring, wounds
Bortz 2015 ²⁷	Expert opinion	Journal of Trauma Nursing	Geriatric and trauma model of care
Botella-Carretero et al. 2010 ²⁸	Randomised controlled trial	Clinical Nutrition	Nutrition and geriatric
Brown et al. 2017 ⁴	Systematic review	Injury Prevention	Injury and older person
Carpenter et al. 2017 ²⁹	Expert opinion and case study	Emergency Medicine Australia	Trauma in the older person
Cawood et al. 2012 ³⁰	Systematic review and meta-analysis	Ageing Research Review	Supplements and disease. Wound healing
Cheung et al. 2017 ³¹	Outcome study	Journal of the American College of Surgeons	Geriatric trauma
Cook et al. 2016 ³²	Prognostic study	Journal of Trauma and Acute Care Surgery	Geriatric, elderly, trauma, prognosis
Cowman et al. 2011 ³³	Survey study	Journal of Clinical Nursing	Wound management, tissue repair education
Cross et al. 2016 ³⁴	Retrospective descriptive review	Australasian Emergency Nursing Journal	Wound and skin injuries, nursing
Demidova-Rice et al. 2012 Part 1 ³⁵	Expert opinion	Advances in Skin and Wound Care	Acute wound healing pathophysiology
Demidova-Rice et al. 2012 Part 2 ³⁶	Original investigation	Advances in Skin and Wound Care	Acute wound healing pathophysiology. Impaired healing
Ding et al. 2017 ³⁷	Observational study	Journal of Wound Care	Surgical wound. Postoperative wound care. Assessment and documentation. Nursing
Dinh et al. 2017 ³⁸	Retrospective descriptive design	Injury	Age-related trauma systems
Dugdall & Watson 2009 ³⁹	Survey design study	Journal of Clinical Nursing	Nurses' attitude, evidence-based practice, wound care
Duvall et al. 2015 ⁴⁰	Cohort study	Journal of Palliative Medicine	Geriatric trauma, injury severity, comorbidities

Table 3 continued. Overview of published studies

Author and year	Design	Article source	Extracted themes and relevance to review / inclusion criteria
Dyer et al. 2018 ⁴¹	Review of concepts. Expert opinion	Journal of Clinical and Aesthetic Dermatology	Skin fragility and ageing
Edwards et al. 2017 ⁴²	Longitudinal pre/post	Journal of Clinical Nursing	Prevalence and severity of wounds in the aged
Ellis et al. 2017 ¹⁵	Systematic review	Cochrane Database of Systematic Reviews	Comprehensive geriatric assessment processes improve outcomes
Gabbe et al. 2013 ⁴³	Comparison study	BMC Health Service Research	Aged and trauma outcomes
Gillespie et al. 2013 ⁴⁴	Survey study	Journal of Clinical Nursing	Wound care. Nursing practices
Gitajn et al. 2017 ⁴⁵	Retrospective comparative study	Journal of Orthopaedic Trauma	Geriatric trauma survival
Greenhalgh 2015 ⁴⁶	Expert opinion	Surgical Clinical North America	Management of skin and soft tissue. Geriatric
Fagard et al. 2016 ⁶	Systematic review	Journal of Geriatric Oncology	Frailty in the aged
Hahnel et al. 2017 ⁴⁷	Systematic review	Journal of Tissue Viability	Skin and the aged person
Hashmi et al. 2014 ²	Systematic review and meta-analysis	Journal of Trauma Acute Care Surgery	Geriatric mortality predictors in trauma
Hazeldine et al. 2015 ¹	Review, expert opinion	Ageing Research Review	Geriatric and trauma outcomes
Hilderbrand et al. 2015 ³	Review of literature	Journal of Emergency Surgery	Impact of aged on trauma clinical outcomes
Joseph 2015 ⁴⁸	Expert opinion	Injury	Elderly and trauma burden / opportunity
Joseph et al. 2014 ⁸	Prospective cohort study	Journal of the American Medical Association	Frailty, age, trauma, geriatric, predicting outcomes
Joyce et al. 2015 ¹⁴	Review	Current Opinion Anesthesiology	Elderly, frailty, geriatric, trauma
Koenen et al. 2015 ⁴⁹	Comparative study	International Wound Journal	Acute and chronic wound fluid. Impaired wound healing
Li et al. 2017 ⁵⁰	Systematic review	International Wound Journal	Wound care
Malek et al. 2018 ⁵¹	Expert opinion	Oxidative Medicine and Cellular Longevity	Ageing
McDonald et al. 2016 ⁷	Systematic review	Journal of Trauma and Acute Care Surgery	Elderly and frailty in trauma
Milne et al. 2009 ⁵²	Intervention review	Cochrane Database of Systematic Reviews	Protein and energy supplements in elderly at risk of malnutrition
Müller et al. 2017 ⁵³	Cross-sectional study and prospective study	European Journal of Clinical Nutrition	Impaired nutrition, geriatric and trauma population

Table 3 continued. Overview of published studies

Author and year	Design	Article source	Extracted themes and relevance to review / inclusion criteria
Noblet et al. 2018 ⁵⁴	Cohort study	Injury	Managing soft tissue in the ageing population. Limb trauma
O'Leary et al. 2017 ⁵⁵	Retrospective review	The New Zealand Medical Journal	Older people and trauma
Qing 2017 ⁵⁶	Expert opinion. Education document	Chinese Journal of Traumatology	Wound healing, non-wound healing
Reddy et al. 2008 ⁵⁷	Expert opinion. Education document	Advances in Skin and Wound Care	Skin and wound repair in the older adult. Normal verses abnormal changes. Pathophysiology
Sen et al. 2009 ⁵⁸	Perspective article	Wound Repair and Regeneration	Wound. Public health. Ageing population
Serra et al. 2017 ⁵⁹	Systematic review	International Wound Journal	Skin tear, risk, elderly, nursing
Soysal et al. 2016 ⁹	Systematic review and meta-analysis	Ageing Research Review	Elderly. Frailty
Sgonc et al. 2013 ⁶⁰	Mini review. Expert opinion	Gerontology	Wound healing and the aged
Ubbink et al. 2015 ¹³	Prognostic study	International Wound Journal	Predicting complex acute wound healing based on clinical awareness
Volkert et al. 2018 ⁶¹	Guideline	Clinical Nutrition	Nutrition and the elderly
Welsh 2017 ⁶²	Semi-systematic review	International Wound Journal	Wound care, nursing, education
Wounds Australia 2016 ¹²	Guideline	Wound Australia	Management of wounds
Wuthisuthimethawee et al. 2014 ⁶³	Expert opinion	World Journal of surgery	Wound management, trauma

often determinant by return to work and education status, which is often not relevant in this population⁴.

Focusing on pre-existing medical conditions and wounds, there is evidence that diabetes and vascular disease directly impact wound healing. The epithelialisation process is impaired in all types of chronic wounds with extended pro-inflammatory characteristics⁶⁵. When an acute traumatic wound fails to heal, in the absence of infection and frailty, pre-morbid conditions can be a major cause. Vascular disease and diabetes are the main disease processes identified in chronic wounds. Optimising and treating these underlying conditions gives the best chance of wound healing.

Vascular disease is predominantly venous, arterial or mixed presentation, which impacts the macro-circulation and microcirculation of tissue. Insufficient perfusion and hypoxia cause impaired angiogenesis, collagen deposit and epithelialisation⁵⁰.

The WHO global report on diabetes details a rise in adults living with diabetes, with estimates of 422 million worldwide⁶⁷. This same report stated mortality from diabetes-related complications (heart attack, stroke, blindness, kidney failure and lower limb amputation) in 2012 was 1.5 million globally⁶⁷. Systemic oxidative stress is the underlying trigger, impacting on microvascular endothelial cells due to hyperglycaemic-induced damage⁶⁸. Activation of five intracellular pathways being triggered is the major causative factor in microvascular disease, and the resulting tissue damage, in diabetes⁶⁸.

Nutrition and healing

In the over 65 years age group, malnutrition is common across all healthcare settings and in the community. The mechanism of malnutrition may be physiological, psychological, economical, educational or social. Malnutrition can be attributed to both the cause and the consequence of ill health, and a contributing factor in sarcopenia, osteoporosis, poor

wound healing and vulnerability to disease⁵³. There is a direct correlation between falls and the presence of sarcopenia and osteoporosis³⁰.

Nutrition and the presence of malnutrition have been the subject of many higher-level studies. Studies which concentrated on geriatric, trauma or wounds were reviewed. These studies concluded the need for all older patients to be assessed for malnutrition and for diligent efforts to ensure adequate nutrition, and were supportive of a high energy, high protein diet for all at-risk patients^{12,61}. The causal relationship to nutrition and healing continues to be a growing analysis / area of study. Blass et al.'s RCT found improved time to heal when antioxidant micronutrients and glutamine supplements were dispensed in disorders of wound healing in trauma patients²⁵. They hypothesised delayed healing was due to oxidative burden, increased cell requirements and elevated inflammation, which reduced albumin levels needed to facilitate the micronutrient transport to the wound. This study was adult traumatic wound-specific, with age not a consideration. Of the patients randomly selected to the placebo, 67% were in the 65 years and above category.

Muller et al.⁵³ studied the malnutrition of older trauma patients at time of injury, and concluded there was a two-fold greater odds of a poorer outcome when malnourished compared to the patients who were well nourished at the time of the injury. They also found a correlation between frailty and malnutrition. Botella-Carretero et al.'s RCT introduced oral nutritional supplements prior to hip fracture surgery in the older population²⁸. The results showed the intervention group had less complications post-operation, hypothesising the reason for this was the increase in serum protein. There was inconclusive evidence for reduced mortality and decreased length of stay in this study. Cawood et al.'s systematic review and meta-analysis supported Botella-Carretero et al.'s finding of reduction in complications with high protein oral supplements^{30,28}. This study looked at hospitalised older patients, with a subgroup of nutritional impact on healing. They postulated the positive impact of proteins on inflammatory and immune function. While the focus was on skin tears, Serra, Ielapi, Barbetta and de Franciscis identified abnormal albumin levels related to nutrition deficits was an independent risk factor to skin integrity breakdown⁵⁹. Volkert et al.'s guideline on clinical nutrition and hydration in geriatrics supported the implementation of nutritional screening and oral nutritional supplements for all older patients due to the benefits to clinical resilience and quality of life⁶¹. This focused on sarcopenia and its association with impaired metabolic adaptation to stress and disease, and its direct relation to frailty.

The Cochrane review by Milne, Potter, Vivanti and Avenell⁵² supported the findings of reduction of complications in this surgical population with oral nutritional supplements. The research they reviewed was unable to find an association with supplements reducing mortality, decreased length of

stay, nor improving quality of life. They were critical of the gaps in adequate screening of patients and different meanings of definition related to nutritional status. It was concluded, "Most individual's studies in this review had an intervention time that was too short to have a realistic chance of detecting differences in morbidity, functional status or quality of life"^{52(p.16)}.

Infection and healing

Traumatic wounds have a high risk of infection due to the nature of the 'dirty' mechanism of injury. Suboptimal wound management, especially early in the patient's trauma journey, results in more extensive infection, tissue necrosis, extra surgical intervention, and more complex closure options⁶³. In the traumatic wound, elevated rates of infection follow contamination, tissue loss, inadequate cleaning and debridement, and early wound closure⁶³. The wound environment and patient factors generate the greatest risk of infection. Contamination is through microorganism on the patient, environmental contaminants at the time of trauma, and from cross-contamination through clinician wound technique⁶⁹.

The WHO wound management statement recommends recognising the standard classification of trauma wounds as contaminated⁷⁰. They recommend delaying closure of traumatic wounds to ensure adequate debridement of foreign or infected material. Delayed primary closure should be the first option if approximation of wound edges makes this a viable option. Representing a global burden on health, the most common adverse event affecting patient safety are hospital acquired infections⁷¹. Traumatic and surgical site infection are a serious and costly complication for the trauma patient and the health organisation. As well as causing increased pain and suffering, they increase the risk of mortality, morbidity and hospital length of stay. To achieve a standardised best practice approach, effective infection prevention and control measures need to be established with each clinician interaction⁷². Sepsis also remain a common cause of trauma mortality. Patients have a higher susceptibility to infection with traumatic wounds, malnutrition, pre-existing conditions and frailty⁷³.

Clinician education

Clinician knowledge is paramount in wound healing to achieve successful outcomes. Welsh's semi-systematic review aimed to define the level of evidence supporting nursing wound care decision-making and practice⁶². Welsh established that evidence was limited in wound care practice, and nurses were found to rely on informal sources of knowledge to structure wound care. Further to this, Welsh found ritualistic cultures and inadequate wound care educations at all levels of practice⁶².

The descriptive cross-sectional survey design study by Gillespie, Chaboyer, Allen, Morely and Nieuwenhoven⁴⁴ found nurses surveyed had an appropriate knowledge

of wound healing; however, evidence-based practices (EBP) were lacking in their wound care. In this convenient sample study, 59% of nurses were unaware of the national standards for wound care, and over 70% reported not using practice standards in their wound care. The cross-centre survey design study by Dugdall and Watson³⁹ found nurses with higher academic qualifications demonstrated higher clinical knowledge and usage of EBP wound care. Edwards et al.'s pre/post-design study⁴² demonstrated the significant decrease in preventative wound occurrence, improvement skin integrity and increased EBP wound management with wound champions. Ding, Lin, Marshall and Gillespie's cross-sectional observational study looked at wound practice alignment to EBP guidelines, and found practices did not consistently align to guidelines³⁷. The international eDelphi study, by Cowman et al.³³, disclosed improved clinician education as number five of the top ten wound priorities from the international respondents. A significant issue discovered in this study was the need for a better understanding of wound bed assessment, wound dressing function, and selection.

Conclusion

The raw statistics in the trauma population overwhelmingly dictate age as an independent factor of poor outcome. Using the research to improve practices and outcomes requires looking at more specific factors within the older population. In this scoping review, frailty, malnutrition, pre-existing comorbidities and clinician education have been appraised regarding their impact on healing and outcomes. Infection has been acknowledged as having an impact on healing and outcome. Controlling and optimising pre-existing medical conditions is vital in the trauma population to assist in the resilience required to maintain homeostasis. Trauma wounds are compromised by pre-existing comorbidities, most notably by vascular disease and diabetes. With the impacts of malnutrition enhancing frailty, falls and fragility to comorbidities, improving and optimising nutrition is essential for good outcomes following trauma. The importance of nutrition in wound healing, infection prevention and decreased susceptibility to infection and sepsis has also been recognised in the literature.

As established by the international guidelines and position statements, clinician skill and knowledge is essential for preventing harm and promoting healing and recovery. Disseminating the knowledge and skill to ensure best practice is a continual and challenging issue in the busy clinical environment. Rituals and unsupported practices need to be replaced by those engaging, educating and guiding clinicians in best practice and wound knowledge and skill.

It has been established that the burden to the health system, the individual and the community when a person sustains a traumatic injury is significant. The older patient population are over-represented in poor health outcomes relating to mortality, morbidity, length of stay and delayed

wound healing compared to the younger trauma patient. The findings of searched articles and studies that discuss the impact of age on healing in the acute trauma setting have been presented.

This scoping review has exposed some points for consideration and discussion to improve clinical practice in this vulnerable patient population. The emerging consensus favours the impact of frailty rather than age as having a greater physiological impact on the outcome, resilience and healing. The frail patient is more susceptible to comorbidities, malnutrition and poor outcomes. Clinician support, education and engagement is required to improve the management of pre-existent comorbidities, optimise nutrition, prevent infection, utilise best practice standards in care, and have a complex understanding of wounds and healing. With an increasing ageing population globally, specialised knowledge, guidelines and structures to support geriatric care are paramount.

Conflict of interest

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