

Human Wounds and Its Burden: An Updated Compendium of Estimates

Chandan K. Sen^{1,2,*}

¹Department of Surgery, Indiana University Health Comprehensive Wound Center, Indianapolis, Indiana.

²Editor-in-Chief, *Advances in Wound Care*

Significance: A 2018 retrospective analysis of Medicare beneficiaries identified that ~8.2 million people had wounds with or without infections. Medicare cost estimates for acute and chronic wound treatments ranged from \$28.1 billion to \$96.8 billion. Highest expenses were for surgical wounds followed by diabetic foot ulcers, with a higher trend toward costs associated with outpatient wound care compared with inpatient. Increasing costs of health care, an aging population, recognition of difficult-to-treat infection threats such as biofilms, and the continued threat of diabetes and obesity worldwide make chronic wounds a substantial clinical, social, and economic challenge.

Recent Advances: Chronic wounds are not a problem in an otherwise healthy population. Underlying conditions ranging from malnutrition, to stress, to metabolic syndrome, predispose patients to chronic, nonhealing wounds. From an economic point of view, the annual wound care products market is expected to reach \$15–22 billion by 2024. The National Institutes of Health's (NIH) Research Portfolio Online Reporting Tool (RePORT) now lists wounds as a category.

Future Directions: A continued rise in the economic, clinical, and social impact of wounds warrants a more structured approach and proportionate investment in wound care, education, and related research.

Keywords: human wound burden, wound care economics, military wound care, wound care training and education



Chandan K. Sen, PhD

Submitted for publication January 15, 2019.
Accepted in revised form January 15, 2019.

*Correspondence: Department of Surgery, Indiana University Health Comprehensive Wound Center, 975 W Walnut Street, Indianapolis, IN 46202 (e-mail: cksen@iu.edu)

INTRODUCTION

A 2009 REVIEW OF THE state of human skin wounds and the threat they present to public health and the health care economy provided an overview of the far-reaching impact of chronic wounds. There is a need for allocation of resources to understand the mechanistic basis of cutaneous wound complications.¹ The current article is intended to provide an update on the rising threat that chronic wounds present to global health and economy. A recent retrospective analysis of the Medicare 5% dataset for 2014 analyzed all wound cate-

gories, including acute and chronic wounds, and identified that about 8.2 million Medicare beneficiaries had at least one type of wound or related infection.² Medicare cost projections for all wounds ranged from \$28.1 billion to \$96.8 billion, including costs for infection management, among which surgical wounds and diabetic ulcers were the most expensive to treat.² Furthermore, outpatient costs (\$9.9–\$35.8 billion) were higher than inpatient costs (\$5.0–\$24.3 billion), possibly because of an increase in outpatient wound treatments that are currently provided.²

CHRONIC WOUNDS

Wounds that have not progressed through the normal process of healing and are open for more than a month are classified as chronic wounds.³ There are varying etiologies of chronic wounds, all of which burden the health care system. Patients suffering from diabetes and obesity are at a high risk of developing chronic wounds. A vast majority of the people who have a prolonged open wound usually also have other major health conditions. The simultaneous presence of a combination of chronic diseases is called a comorbidity. Chronic wounds are often complicated by comorbidities, making it difficult to track chronic wounds as a disease in itself.³ As such, research funding directly addressing the study of chronic wounds is disproportionately low compared with the overall impact of chronic wounds as a health care problem.^{4,5} National Institutes of Health has recently set up the first consortium of its kind, a national Diabetic Foot Consortium (NIDDK; FOA: DK17-014; NOT-DK-18-017), aimed at bringing experts across the United States together to improve the care of diabetic foot ulcers (DFUs).

Chronic wounds are mostly seen in the elderly population.^{2,6} In the United States, 3% of the population >65 years of age have open wounds. By 2020, the US government estimates that the elderly population will be over 55 million, suggesting that chronic wounds will continue to be an increasingly persistent problem in this population.⁷ Overall, in the United States ~2% of the total population are estimated to be affected by chronic wounds.⁸ The impact of chronic wounds is also adverse worldwide. For example, a 2016 report from Wales estimated a 6% prevalence of chronic wounds with a 5.5% cost to the National Health Service (NHS).⁹

In the world's largest wound-dressing markets, United States and Europe, there is a significant demand for wound care products. Globally, the annual cost for wound care was an average of \$2.8 billion in 2014. It is projected to rise up to \$3.5 billion in 2021.¹⁰ The 2018 market research report predicts that the global wound-closure products market will exceed \$15 billion by 2022.¹¹ The advanced wound care market targeting surgical wounds and chronic ulcers is expected to exceed \$22 billion by 2024, driven by technological advancement, rising incidences of chronic wounds, increasing government support, and a rising geriatric population.¹²

PRESSURE ULCERS

Pressure, or pressure in combination with shear and/or friction, promotes the development of lo-

calized ulcers called pressure ulcers (PUs). PU care is expensive and costs more than \$11 billion annually in the United States per the Agency for Healthcare Research and Quality (AHRQ) statistics.¹³ Cost of individual patient care ranges from \$20,900 to \$151,700 per PU.¹³ Apart from hospital costs, additional charges for food, transportation, and maintenance is ~\$43,180 per year.¹³ Elderly patients; patients with stroke, diabetes, dementia; and those with impaired/limited mobility or sensation are extremely vulnerable to PU. Prolonged sedentary stays in the intensive care unit can also drive PU development in otherwise healthy patients.

The incidence of PU increases with age and is promoted by a lack of skin perfusion, moisture, and nutrition.¹⁴ In the United States around 2.5 million people develop PUs annually.¹³ They are usually preventable, but they can be lethal if proper, timely care is not received.^{15–19} The global market for PU care products is expected to reach \$4.5 billion by 2024.²⁰ Factors that spur this increase include the aging population and associated mobility and neurological disorders.²⁰

DIABETES

The Centers for Disease Control and Prevention (CDC) recently released a study that indicated that more than 100 million adults are living with diabetes or prediabetes in the United States.²¹ As of 2015, 30.3 million Americans (9.4% of the US population) live with diabetes; besides, 84.1 million have prediabetes, which if left untreated often leads to type 2 diabetes (T2D) within 5 years.²¹ Diabetes prevalence has been found to increase with age. Four percent of adults aged 18–44, 17% of adults aged 45–64 years, and 25% of those aged ≥65 years have diabetes.²¹

Worldwide, there are an estimated 400 million people living with diabetes.²² In reference to the statistical studies by the World Health Organization (WHO) in 91 countries globally, it was identified that a tiny island country in Micronesia, Nauru, had the highest prevalence rate of 30.9% in 2010.²³ This was projected to rise to 33.4% by the year 2030.²³ United Arab Emirates was next in line with 18.7% prevalence in 2010, and a projected increase to 21.4% in 2030.²³ The age of diabetes onset in developing countries is 45–64.²⁴ By 2030 it is predicted that developing countries will have more people (>65 years of age) with diabetes (82 million) than developed countries (48 million).²⁵

The prevalence of foot ulcers (FUs) is high in the diabetic population and has a neuropathic origin.^{26,27} The annual prevalence of FUs is estimated

to be 4–10%, and the risk of development of these ulcers in diabetics is estimated to be anywhere from 15% to 25%.²⁸ The management of DFUs costs \$9–\$13 billion in the United States.²⁶

By 2026, the T2D market is expected to rise from \$28.6 billion to an estimated \$64 billion. A compound annual growth of 8.4% is expected in the United States, France, Germany, Italy, Spain, the United Kingdom, and Japan.²⁹ In the United States, the demand for insulin pumps is expected to rise to a \$3.8 billion business by 2022, driven by the increasing number of people with diabetes, as well as technological advances in treatment.³⁰

FOOT ULCERS

An open sore on the foot is called a FU. It may be shallow, confined only to the surface of the skin. Deep FUs can involve full thickness of the skin, muscle, tendons, and bones. FUs are common in people with diabetes and individuals with compromised blood circulation.³¹ Despite advanced health care and pharmacotherapy techniques that are widely available, the prevalence of FU has not changed in the past two decades.³² Fourteen percent to 24% suffer from amputation.³³ Neuro-ischemic ulcers are particularly associated with limb amputations.²⁷

Recently, a systematic review and meta-analysis of the global epidemiology of FUs was performed using PubMed, EMBASE, ISI Web of Science, and Cochrane database searches. This was the largest analysis of its kind, including >800,000 subjects from 33 countries. The global DFU prevalence was found to be 6.3%. The lower prevalence of DFU in Europe (5.1%) compared with North America (13.0%) presents a striking difference. Out of 33 countries, Belgium had the highest prevalence with 16.6% and Australia the lowest with 1.5%. Men appeared to be more prone to FUs than women (4.5% vs. 3.5%). Furthermore, FUs were seen more often in patients with T2D compared with type 1 diabetes (6.4% vs. 5.5%).^{34,35} In general, patients with FUs were older, had a lower body mass index (BMI), longer diabetes duration, higher hypertension rates, higher incidence of diabetic retinopathy, and a smoking history, compared with those without FUs.

The global DFU market expects a positive 6.6% compound annual growth rate between 2016 and 2024. At this pace, the market's valuation may reach \$4.9 billion by the end of 2024. Regionally, the United States dominated the global market in 2016 with an estimated share of 38.1%. It is expected to remain dominant through the forecast period (2024).³⁶

VENOUS ULCERS

A vast majority (70%) of lower-extremity ulcers are caused by chronic venous insufficiency.³⁷ In the United States and Europe, people >65 years of age are vulnerable to venous ulcers.³⁸ The prevalence of venous ulcers is 1% of the population globally among those aged 18–64.³⁹ In the United States, 10–35% of the population suffer from some kind of chronic venous issues with 4% (>65 age group) of the cases having active ulcers.⁴⁰ In the United States and the United Kingdom, venous leg ulcers cost around \$2.5 billion and £300–600 million, respectively.⁴¹ The annual expenditure to treat a venous ulcer is estimated at \$10,563.⁴² For chronic, nonhealing venous ulcers, the treatment expenditure is estimated to be ~\$34,000 or higher.⁴² Chronic venous ulcers burden economic productivity by resulting in the loss of 4.6 million work-days per year.⁴³

OVERWEIGHT AND OBESITY

According to a recently updated report from the WHO, worldwide obesity has nearly tripled between 1975 and 2016.⁴⁴ Excessive accumulation of fat complicates numerous aspects of vital functions within the body, causing illness and posing a risk for an increase in additional health complications. For adults, WHO defines overweight as a BMI ≥ 25 . Obesity is defined as a BMI ≥ 30 .⁴⁴ Estimates from 2016 indicated that 39% of adults (1.9 billion; ≥ 18 years) worldwide were overweight, and 13% (>650 million) were obese.⁴⁴ Among these, women were more prone to overweight or obesity than men. The threat of obesity is not a menace only for adults. Globally, 340 million children and adolescents, aged 5–19, were overweight or obese in 2016.⁴⁴ In children <5 years, 41 million were either overweight or obese.⁴⁴

Overweight and obese are at a high risk for noncommunicable diseases^{44–46} such as:

- Cardiovascular diseases (primarily heart disease and stroke)
- Diabetes and associated chronic wounds
- Musculoskeletal disorders
- Some cancers (including endometrial, breast, ovarian, prostate, liver, etc).

Childhood obesity^{47,48} is associated with a predisposition to breathing difficulties, increased tendency toward fractures, hypertension, increased risk of cardiovascular disease, insulin resistance, and psychosocial impacts.^{49,50}

In adults, the association between obesity and multiple complications such as impaired or totally

failed cutaneous wound healing, particularly following surgery, has been identified by various groups.^{51–60} Being overweight or obese significantly increases the likelihood of infection-related complications compared with those within a healthy weight range.⁶¹ There are many factors that contribute to the chronicity of infection in obese people. Decreased vascularization of the adipose tissue is a major cause for increased infection in obese patients.⁵³ Such poor perfusion limits the supply of host immune cells that represent key components of host defenses against infection.^{53,62–64}

In obese individuals, intentional weight loss was associated with ~15–18% reduction in all-cause mortality.^{65,66} Intra-gastric balloons (IGBs) are the leading treatment options for obesity and associated diseases. The growing acceptance of minimally invasive surgical methods for IGB insertion is expected to fuel the rising use of this methodology. The IGB market value is expected to exceed \$270 million by 2024.⁶⁷

PERILS OF CHRONIC WOUNDS

Access and delivery of wound care are both significant problems that challenge patients suffering from chronic wounds. Lack of access to specialized wound care has resulted in amputations and loss of work productivity.^{8,68–70} In the United States, chronic ulcers are conservatively estimated to cost the health care system \$28 billion each year as a primary diagnosis and up to \$31.7 billion as a secondary diagnosis.⁷¹ According to the American Diabetes Association (ADA), over 9–12 million Americans suffer from chronic ulcers.⁷² The mortality rate for leg ulcers after the first amputation has dramatically doubled from 20% to 50% in the first 3 years to 70% after 5 years.⁷² There is a profound psychological impact on the patients suffering from chronic wounds, such as loneliness, separation from an active social life, and depression. These psychosocial stressors further worsen healing outcomes.^{73,74}

ACUTE WOUNDS

Disruptions in the integrity of the skin that heals uneventfully with time are considered acute wounds.³ Surgical and traumatic wounds, abrasions, or superficial burns are generally considered acute wounds.³ Every time the integrity of the cutaneous barrier is compromised, a wound is created. Wound infections complicate recovery from surgery and significantly increase the cost of wound care postsurgery. The development of novel and practical concepts to prevent and treat these

wound infections are key to effective wound management.

In 2014, acute wounds resulted in 17.2 million hospital visits, including ambulatory/outpatient and inpatient surgical visits.⁷⁵ The majority (57.8%) of these visits occurred in hospital-owned outpatient settings, while 42.2% were inpatient.⁷⁵ Outpatient visits were primarily (48.6%) covered by private insurers, while Medicare primarily (43.4%) covered inpatient surgical stays.⁷⁵

Hospital discharge data derived from the Healthcare Cost and Utilization Project (HCUP) from burn-related hospital inpatient stays and emergency department visits identify that although there have been significant improvements in treatment options for burn injuries, the frequency and associated costs of these injuries remain high.⁷⁶ Almost half million patients were treated for burns in 2011. Costs estimates show that ~\$1.5 billion was spent in burn injury care in 2010. An additional \$5 billion in costs was associated with lost work-hours. The length of inpatient stay of burn patients was estimated to be twice that of nonburn-related stays.⁷⁶

Surgical site infections (SSI) represent a major concern in overall health care in the United States and worldwide.^{77–79} It is the second leading cause of hospital-acquired infections costing \$3.5–\$10 billion per year.^{80,81} Despite all efforts, SSI contributes to mortality in 75% of cases.^{82,83}

Emergency wound care for acute wounds has relevance in combat settings and preparedness against natural disasters, terrorist attacks, and other such events that result in acute injuries. Survivors of bombings are primarily impacted at the soft tissue and musculoskeletal system level.⁸⁴ Amputations are the unfortunate end result of the most extreme of these injuries and reported to occur in 1–3% of blast victims.^{84,85} Acute wound care accompanied by associated infections may highly impact occupational health.

INFECTION

Bacteria rapidly colonize in open skin wounds after burn injury^{86–90} or surgical incisions.^{51,91–96} Microorganisms colonizing these wounds are typically the patient's normal flora^{97–101} or may be transferred via contact with contaminated water, fomites, or the soiled hands of health care workers.^{102–106} Gram-positive bacteria such as *Staphylococcus aureus*, *Enterococcus* spp., and Gram-negative organisms such as *Pseudomonas aeruginosa*, *Acinetobacter* spp., fungi like *Candida* spp., *Aspergillus* spp., are all among a list of common

pathogens that can cause acute wound infections, and several of them are resistant to antibiotics.¹⁰⁷

An important factor in the failure of a sore to heal is the presence of polymicrobial consortia, living cooperatively in highly organized biofilms. The biofilm shields the pathogenic microbes from antimicrobial therapy and the patient's immune response. Biofilm infections have been linked to wound chronicity.^{89,90,108–112} Recent studies reveal that biofilm infection may directly hinder wound closure or cause defective wound closure where the wound site appears closed but the repaired skin lacks barrier function.^{87,89,90,112} Such observation calls for a revision of the current wound care endpoint. Covering of a wound and a lack of discharge may not be adequate criteria to declare a wound closed. It is important to add that the repaired skin must have physiological functionality. Thus, covering of the wound, a lack of discharge, and restoration of barrier function should be considered as criteria for wound closure in patients. It is suspected that wounds that appear closed, but are deficient in barrier function, lend themselves to wound recurrence. Patient-based studies (NCT 02577120) are currently in progress to test this hypothesis.

MALNUTRITION

The process of wound healing, involving *de novo* tissue generation, is a metabolic and calorie-demanding process. From a microenvironment standpoint, energy needs to be generated to enable cellular repair mechanisms, chemotactic responses (growth factors and cytokine response), cell motility, division, and differentiation.^{113,114} At a macro-environment scale, patients with nonhealing wounds often suffer from nutritional deficiencies.¹¹⁵ Those with, compared with those without, nutritional deficits are more likely to develop chronic wounds that are slower to heal.^{116–118}

STRESS

Another key determinant relating to wound outcomes is psychosocial stress.^{52,73,119–122} Stress impairs cellular immunity, compromising wound healing. The discipline of psychoneuroimmunology (PNI) is of direct relevance to wound healing outcomes.^{123,124} PNI provides a key insight into how the immune system bi-directionally communicates with the central nervous and endocrine systems and how these communications impact health outcomes.^{123,124} Stress-induced immune dysregulation results in impaired wound healing.^{123,125,126}

SCAR AND FIBROSIS

Scars and associated functional as well as aesthetic concerns represent a huge burden on health care.¹²⁷ Burn wounds usually leave hypertrophic scars after they have healed. In particular, the face is highly susceptible to excessive scarring, causing functional deficits. Some of the critical facial characteristics following thermal injury of the face include ectropion (epithelial-ocular junction), eversion of the lip (epithelial-oral junction), and excessive skin contracture. Deficits such as oral incompetence are common. Such disorders cause social, emotional, and psychological burdens. Patients with such facial disfigurements showed symptoms of depression, anxiety, and hostility, compared with a matched normal control group, for a period of up to 1 year post trauma.¹²⁸ Other than the face, scarring is a substantial health care problem today. The global skin scar therapy market is expected to reach around \$35 billion by 2023.¹²⁹

PHYSICIAN EDUCATION

Comprehensive education is critical for the development of wound care management as a discipline in mainstream medicine.¹³⁰ Formal wound care education in US medical schools is often weak at best. Of 55 schools surveyed throughout the United States, only seven offered a formal wound healing elective.¹³¹ Typically, education and training in wound care for the medical students within the United States do not exceed >9.2 h in the 4-year curriculum.¹³² To help address this gap in medical training, the American College of Wound Healing and Tissue Repair was founded to help train physicians specialize in wound care. This institution is currently working toward accreditation by the American Board of Medical Specialties and hopes to achieve this by 2022.¹³⁰

In Europe, wound care education lacks consensus in relation to the minimum education needed to be an expert in wound care.¹³³ Various diploma and certificate programs are available in France, England, and Wales. The European Wound Management Association (EWMA) is working toward establishing a core standard for acceptable wound management education.¹³³ In Denmark, however, a 2-year additional educational experience following basic specialty training has been developed for medical doctors.¹³³

NURSING EDUCATION, PHYSICAL THERAPY, AND OSTOMY

Traditionally, wound healing has been under the aegis of basic nursing practices,¹³⁴ such as wound

covering management, therapeutic nutrition, and mobility and psychosocial support. Nurses play a crucial role in handling and managing acute wounds and chronic wounds such as PUs, bedsores, FUs, and venous ulcers. The Wound Ostomy and Continence Nurses (WOCN) Society is the oldest wound care society that has board-certified over 6,000 nurses worldwide.¹³⁴ They are considered the gold standard for certification in wound nursing, and this process requires completion of a rigorous curriculum followed by stringent recertification processes.¹³⁴ In 2010, the Organization of Wound Care Nurses (OWCN) was established.¹³⁵ It provides the foundation and free-of-cost training for all the licensed nurses who are practicing in different care settings. Wound care and ostomy education programs for nurses are increasingly becoming available in an effort to improve nursing service quality.¹³⁶

Appropriate professional use of multiple wound care disciplines may markedly impact wound care.^{137–139} Physical therapy represents one such major discipline. Trained physical therapists may employ numerous treatment regimens, such as wound debridement, modalities, edema management, positioning, orthotic use, and mobility improvement. Occupational therapists may provide edema management, wound debridement, positioning, toileting programs, self-feeding, and wheelchair management as relevant to the need of the patient. Addressing supportive interventions such as physical and occupational therapy and nutrition management are likely to promote the rate of wound healing, thereby lowering the overall costs of wound care. After all, the longer a patient's healing time, the higher the cost to the facility.

Wound, ostomy, and continence nurses, in addition to being educated and trained to provide acute and rehabilitative care, represent an important component of the wound care ecosystem.^{140–142} Ostomies, stomas, acute and chronic wounds, and urinary and fecal incontinence often present severe physical challenges to wound patients. These lead to emotional and social issues that may be addressed by properly trained allied medical professionals. Limitations in well-structured education of wound care providers may be viewed as a significant barrier to uniform evidence-based wound care throughout the country.

PATIENT EDUCATION

Literature addressing patient-centered wound care has mostly focused on quality of life (QoL), pain, adherence, and coping. A key concern from the patients' perspective is improved provider rec-

ognition of patients' concerns in treatment planning and request for personalized approaches. The evolution to shared wound care decision making is what patients are seeking.^{143,144} Engaging patients' awareness and involvement in wound management is key to ensuring successful healing outcomes.¹⁴⁵

COMBAT WOUND CARE

In the military and related defense services, wounds and trauma are a common problem. In 2017, the National Academies of Science, Engineering, and Medicine reported a new vision for a national trauma care system with the ultimate aim of "zero" preventable deaths after injury to benefit those in combat.¹⁴⁶ This vision is based on studies conducted between 2001 and 2011, which identified that ~75% of combat deaths were caused by explosions and lack of timely and appropriate care before the patient reached a medical treatment facility.¹⁴⁶

The Department of Defense (DoD) and the US Department of Veterans Affairs (VA) are the two federal government institutions involved in providing health care to the 3.9 million US military members who served in Operation Enduring Freedom and Operation Iraqi Freedom (OEF/OIF), the 17 million veterans from prior periods, and the 1.3 million active personnel and their families.¹⁴⁷

The DoD covers active service members, and the VA provides medical support to eligible retirees. The TRICARE for Life program is a wraparound plan meant to supplement Medicare coverage of military retirees and to pay for military hospitals and health care workers.¹⁴⁸ The VA estimates that around 25% of military veterans have diabetes^{149,150} (compared with 9% of the civilian adult population). The economic burden of lower limb amputations in diabetic veterans was \$206 million.¹⁵¹

The Combat Casualty Care Research Program is a collaborative, multidisciplinary partnership that utilizes clinical and translational research to provide state-of-the-art wound care.¹⁵² With an effort to maximize restoration of function and QoL in service members with combat-related extremity trauma, the VA and DoD have increased their research and clinical care efforts with a focus on regenerative medicine.¹⁵³

CLOSING REMARKS

Based on estimates originating from independent sources, it is clear that the magnitude of wounds as

a health care problem is sharply rising. Resources allocated to the education, care, and research of wounds continues to be disproportionately low and deserves strategic attention. A key challenge in all of these three domains—education, care, and research—is the ability to recruit interdisciplinary talent that would work together cohesively as one team.

ACKNOWLEDGMENTS AND FUNDING SOURCES

Work on wound care in this program is supported by the National Institutes of Health awards

R01NR015676, R01GM077185, R01GM108014, R01DK114718, U01DK119099, and R01NR013898.

AUTHOR DISCLOSURE AND GHOSTWRITING

No competing financial interests exist. The content of this article was expressly written by the author listed.

ABOUT THE AUTHOR

Chandan K. Sen, PhD, is the Director of Indiana Center for Regenerative Medicine and Engineering, and is J. Stanley Battersby Chair and Professor of Surgery at Indiana University.

REFERENCES

- Sen CK, Gordillo GM, Roy S, et al. Human skin wounds: a major and snowballing threat to public health and the economy. *Wound Repair Regen* 2009;17:763–771.
- Nussbaum SR, Carter MJ, Fife CE, et al. An economic evaluation of the impact, cost, and medicare policy implications of chronic non-healing wounds. *Value Health* 2018;21:27–32.
- Sen CK, Roy S, Gordillo G. *Wound Healing (Nelligan Plastic Surgery: Volume One)*. Amsterdam, Netherlands: Elsevier, 2017.
- Richmond NA, Lamel SA, Davidson JM, et al. US-National Institutes of Health-funded research for cutaneous wounds in 2012. *Wound Repair Regen* 2013;21:789–792.
- Baquerizo Nole KL, Yim E, Van Driessche F, et al. Wound research funding from alternative sources of federal funds in 2012. *Wound Repair Regen* 2014;22:295–300.
- Gould L, Abadir P, Brem H, et al. Chronic wound repair and healing in older adults: current status and future research. *J Am Geriatr Soc* 2015;63:427–438.
- Serena TE. Are you at risk for chronic wounds? 2015. www.futureofpersonalhealth.com/prevention-and-treatment/are-you-at-risk-for-chronic-wounds (last accessed September 6, 2015).
- Järbrink K, Ni G, Sönnergren H, et al. The humanistic and economic burden of chronic wounds: a protocol for a systematic review. *Syst Rev* 2017;6:15–15.
- Phillips CJ, Humphreys I, Fletcher J, Harding K, Chamberlain G, Macey S. Estimating the costs associated with the management of patients with chronic wounds using linked routine data. *Int Wound J* 2016;13:1193–1197.
- Settipalli S. A Robust market rich with opportunities: advanced wound dressings. June 13, 2015. www.pm360online.com/a-robust-market-rich-with-opportunities-advanced-wound-dressings (last accessed September 20, 2015).
- Wound Closure Products Market Share 2018 Industry analysis, growth, and forecast to 2022. 2018. www.financeswire.com/wound-closure-products-market-share-2018-industry-analysis-growth-and-forecast-to-2022 (last accessed April 23, 2018).
- Advanced Wound Care Market Outlook & Forecasts 2018 to 2024: Global industry research, demand and future industry growth analysis. 2018. www.abnewswire.com/presreleases/advanced-wound-care-market-outlook-forecasts-2018-to-2024-global-industry-research-demand-and-future-industry-growth-analysis_201175.html (last accessed April 23, 2018).
- Berlowitz D, VanDeusen Lukas C, Parker V, et al. Preventing pressure ulcers in hospitals; A toolkit for improving quality of care. In: *Affairs USDoV*, ed. Agency for Healthcare Research and Quality (AHRQ), U.S. Department of Health and Human Services.
- Coleman S, Gorecki C, Nelson EA, et al. Patient risk factors for pressure ulcer development: systematic review. *Int J Nurs Stud* 2013;50:974–1003.
- Beckrich K, Aronovitch SA. Hospital-acquired pressure ulcers: a comparison of costs in medical vs. surgical patients. *Nurs Econ* 1999;17:263.
- Berlowitz D, Vandeusen Lukas C, Parker V, et al. Preventing Pressure Ulcers in Hospitals: A Toolkit for Improving Quality of Care. Rockville, MD: Agency of Healthcare Research and Quality, 2011.
- Lyder CH, Preston J, Grady JN, et al. Quality of care for hospitalized Medicare patients at risk for pressure ulcers. *Arch Intern Med* 2001;161:1549–1554.
- Brem H, Maggi J, Nierman D, et al. High cost of stage IV pressure ulcers. *Am J Surg* 2010;200:473–477.
- Black JM, Edsberg LE, Baharestani MM, et al. Pressure ulcers: avoidable or unavoidable? Results of the national pressure ulcer advisory panel consensus conference. *Ostomy Wound Manage* 2011;57:24.
- Aging population, growing awareness and innovations drive the global pressure ulcer relief products market. 2017. www.strategy.com/MarketResearch/Pressure_Ulcer_Relief_Treatment_Devices_Market_Trends.asp (last accessed April 23, 2018).
- Centers for Disease Control and Prevention. New CDC report: more than 100 million have diabetes or prediabetes. 2018. <https://www.cdc.gov/media/releases/2017/p0718-diabetes-report.html> (last accessed January 5, 2019).
- Ligand (LGND) diabetes candidate positive in Phase II Study. 2017. <https://finance.yahoo.com/news/ligand-lgnd-diabetes-candidate-positive-140302194.html> (last accessed April 23, 2018).
- Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Res Clin Pract* 2010;87:4–14.
- King H, Aubert RE, Herman WH. Global burden of diabetes, 1995–2025: prevalence, numerical estimates, and projections. *Diabetes Care* 1998;21:1414–1431.
- Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the

- year 2000 and projections for 2030. *Diabetes Care* 2004;27:1047–1053.
26. Raghav A, Khan ZA, Labala RK, Ahmad J, Noor S, Mishra BK. Financial burden of diabetic foot ulcers to world: a progressive topic to discuss always. *Therap Adv Endocrinol Metab* 2018;9:29–31.
 27. Alexiadou K, Doupis J. Management of diabetic foot ulcers. *Diabetes Ther* 2012;3:4–4.
 28. Amin N, Doupis J. Diabetic foot disease: from the evaluation of the “foot at risk” to the novel diabetic ulcer treatment modalities. *World J Diabetes* 2016;7:153–164.
 29. Type 2 diabetes market set to soar to \$64bn by 2026. 2017. www.pmlive.com/pharma_news/type_2_diabetes_market_set_to_soar_says_globaldata_1202514 (last accessed April 23, 2018).
 30. United States \$3.8 Billion Insulin Pump Market 2017–2022 with Insulet Corporation, Medtronic, Roche, Animas Corporation and Tandem Diabetes Care Dominating. 2017. <https://globenewswire.com/news-release/2017/08/25/1100546/0/en/United-States-3-8-Billion-Insulin-Pump-Market-2017-2022-with-Insulet-Corporation-Medtronic-Roche-Animas-Corporation-and-Tandem-Diabetes-Care-Dominating.html> (last accessed April 23, 2018).
 31. Publications HH. Foot Ulcers. 2015. www.drugs.com/health-guide/foot-ulcers.html (last accessed October 18, 2014).
 32. Baba M, Davis WA, Norman PE, Davis TM. Temporal changes in the prevalence and associates of foot ulceration in type 2 diabetes: the Fremantle Diabetes Study. *J Diabetes Complications* 2015;29:356–361.
 33. Tresierra-Ayala MÁ, Garcia Rojas A. Association between peripheral arterial disease and diabetic foot ulcers in patients with diabetes mellitus type 2. *Med Univ* 2017;19:123–126.
 34. Zhang P, Lu J, Jing Y, Tang S, Zhu D, Bi Y. Global epidemiology of diabetic foot ulceration: a systematic review and meta-analysis. *Ann Med* 2017;49:106–116.
 35. Schreml S, Berneburg M. The global burden of diabetic wounds. *Br J Dermatol* 2017;176:845–846.
 36. <https://www.prnewswire.com/news-releases/diabetic-foot-ulcers-and-pressure-ulcers-market-to-reach-us49-billion-by-2024-immobility-in-patients-due-to-chronic-ailments-to-fuel-demand-for-treatments-says-tmr-617648423.html> (last accessed January 5, 2019).
 37. Agale SV. Chronic leg ulcers: epidemiology, aetiopathogenesis, and management. *J Ulcers* 2013;2013:9.
 38. Xie T, Ye J, Rerkasem K, Mani R. The venous ulcer continues to be a clinical challenge: an update. *Burns Trauma* 2018;6:18.
 39. Asaf M, Salim N, Tuffaha M. Challenging the use of bandage compression as the baseline for evaluating the healing outcomes of venous leg ulcer-related compression therapies in the community and outpatient setting: an integrative review. *Dubai Med J* 2018;1:19–25.
 40. <https://www.phlebology.org/ii-primary-chronic-venous-disease> (last accessed December 29, 2018).
 41. O'Donnell TF, Jr., Passman MA, Marston WA, et al. Management of venous leg ulcers: clinical practice guidelines of the Society for Vascular Surgery (R) and the American Venous Forum. *J Vasc Surg* 2014;60(2 Suppl):3s–59s.
 42. Ma H, O'Donnell TF, Rosen NA, Iafrafi MD. The real cost of treating venous ulcers in a contemporary vascular practice. *J Vasc Surg* 2014;2:355–361.
 43. Spentzouris G, Labropoulos N. The evaluation of lower-extremity ulcers. *Semin Intervent Radiol* 2009;26:286–295.
 44. World Health Organization. Fact sheet on obesity and overweight. 2015. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight> (last accessed January 2, 2019).
 45. Lauby-Secretan B, Scoccianti C, Loomis D, Grosse Y, Bianchini F, Straif K. Body Fatness and cancer—viewpoint of the IARC Working Group. *N Engl J Med* 2016;375:794–798.
 46. Nyberg ST, Batty GD, Pentti J, et al. Obesity and loss of disease-free years owing to major non-communicable diseases: a multicohort study. *Lancet Public Health* 2018;3:e490–e497.
 47. Güngör NK. Overweight and obesity in children and adolescents. *J Clin Res Pediatr Endocrinol* 2014;6:129–143.
 48. Yanovski JA. Pediatric obesity. An introduction. *Appetite* 2015;93:3–12.
 49. Kalra G, De Sousa A, Sonavane S, Shah N. Psychological issues in pediatric obesity. *Ind Psychiatry J* 2012;21:11–17.
 50. Rankin J, Matthews L, Copley S, et al. Psychological consequences of childhood obesity: psychiatric comorbidity and prevention. *Adolesc Health Med Ther* 2016;7:125–146.
 51. Sandy-Hodgetts K, Carville K, Leslie GD. Determining risk factors for surgical wound dehiscence: a literature review. *Int Wound J* 2015;12:265–275.
 52. Guo S, Dipietro LA. Factors affecting wound healing. *J Dent Res Mar* 2010;89:219–229.
 53. Anderson K, Hamm RL. Factors that impair wound healing. *J Am Coll Clin Wound Special* 2012;4:84–91.
 54. Doyle SL, Lysaght J, Reynolds JV. Obesity and post-operative complications in patients undergoing non-bariatric surgery. *Obes Rev* 2010;11:875–886.
 55. Pierpont YN, Dinh TP, Salas RE, et al. Obesity and surgical wound healing: a current review. *ISRN Obes* 2014;2014:638936.
 56. Shipman AR, Millington GW. Obesity and the skin. *Br J Dermatol* 2011;165:743–750.
 57. Stevens SM, O'Connell BP, Meyer TA. Obesity related complications in surgery. *Curr Opin Otolaryngol Head Neck Surg* 2015;23:341–347.
 58. Goutos I, Sadideen H, Pandya AA, Ghosh SJ. Obesity and burns. *J Burn Care Res* 2012;33:471–482.
 59. Houdek MT, Griffin AM, Ferguson PC, Wunder JS. morbid obesity increases the risk of post-operative wound complications, infection, and repeat surgical procedures following upper extremity limb salvage surgery for soft tissue sarcoma. *Hand (N Y)* 2018;1558944718797336.
 60. Montgomery C, Harris J, Siegel E, et al. Obesity is associated with larger soft-tissue sarcomas, more surgical complications, and more complex wound closures (obesity leads to larger soft-tissue sarcomas). *J Surg Oncol* 2018;118:184–191.
 61. Thelwall S, Harrington P, Sheridan E, Lamagni T. Impact of obesity on the risk of wound infection following surgery: results from a nationwide prospective multicentre cohort study in England. *Clin Microbiol Infect* 2015;21:1008.e1001–e1008.e1008.
 62. Allen DB, Maguire JJ, Mahdavian M, et al. Wound hypoxia and acidosis limit neutrophil bacterial killing mechanisms. *Arch Surg* 1997;132:991–996.
 63. Thomas Hess C. Checklist for factors affecting wound healing. *Adv Skin Wound Care* 2011;24:192.
 64. Dening J. What's the connection between diabetes and wound healing? In: Butler N, ed. *Healthline*. 2017. <https://www.healthline.com/health/diabetes/diabetes-and-wound-healing> (last accessed December 29, 2018).
 65. Kritchevsky SB, Beavers KM, Miller ME, et al. Intentional weight loss and all-cause mortality: a meta-analysis of randomized clinical trials. *PLoS One* 2015;10:e0121993.
 66. Ma C, Avenell A, Bolland M, et al. Effects of weight loss interventions for adults who are obese on mortality, cardiovascular disease, and cancer: systematic review and meta-analysis. *BMJ* 2017;359:j4849.
 67. Intra-gastric Balloon Market to surpass \$270mn by 2024: Global Market Insights Inc. 2017. <https://globenewswire.com/news-release/2017/03/08/933250/0/en/Intra-gastric-Balloon-Market-to-surpass-270mn-by-2024-Global-Market-Insights-Inc.html> (last accessed April 23, 2018).
 68. Augustin M, Brocatti LK, Rustenbach SJ, Schafer I, Herberger K. Cost-of-illness of leg ulcers in the community. *Int Wound J* 2014;11:283–292.
 69. Kim PJ, Evans KK, Steinberg JS, Pollard ME, Attinger CE. Critical elements to building an effective wound care center. *J Vasc Surg* 2013;57:1703–1709.
 70. Driver VR, Fabbi M, Lavery LA, Gibbons G. The costs of diabetic foot: the economic case for the limb salvage team. *J Vasc Surg* 2010;52(3Suppl):17S–22S.

71. Carver T. New study demonstrates the economic costs; medicare policy implications of chronic wounds. <https://www.apwca.org/news/5310449> 2017 (last accessed January 5, 2019).
72. ADA. Economics of wound care. 2015. <https://www.brhmedical.com/healthcare-professionals/#economics> (last accessed December 15, 2018).
73. Gouin J-P, Kiecolt-Glaser JK. The impact of psychological stress on wound healing: methods and mechanisms. *Immunol Allergy Clin N Am* 2011;31:81–93.
74. Kiecolt-Glaser JK, Marucha PT, Malarkey WB, Mercado AM, Glaser R. Slowing of wound healing by psychological stress. *Lancet* 1995;346:1194–1196.
75. Steiner CA, Karaca Z, Moore BJ, Imshaug MC, Pickens G. *Surgeries in Hospital-Based Ambulatory Surgery and Hospital Inpatient Settings 2014*. Rockville, MD: Agency for HealthCare Research and Quality (AHRQ), 2018.
76. McDermott KW, Weiss AJ, Elixhauser A. *Burn-Related Hospital Inpatient Stays and Emergency Department Visits, 2013*. Rockville, Maryland: Agency for Healthcare Research and Quality AHRQ, 2016.
77. Badia JM, Casey AL, Petrosillo N, Hudson PM, Mitchell SA, Crosby C. Impact of surgical site infection on healthcare costs and patient outcomes: a systematic review in six European countries. *J Hosp Infect* 2017;96:1–15.
78. Shepard J, Ward W, Milstone A, et al. Financial impact of surgical site infections on hospitals: the hospital management perspective. *JAMA Surg* 2013;148:907–914.
79. World Health Organization. *Global Guidelines for the Prevention of Surgical Site Infection*. Geneva, Switzerland: WHO (World Health Organization), 2016.
80. Ban KA, Minei JP, Laronga C, et al. American College of Surgeons and Surgical Infection Society: surgical site infection guidelines, 2016 update. *J Am Coll Surg* 2017;224:59–74.
81. Anderson DJ, Podgorny K, Berríos-Torres SI, et al. Strategies to prevent surgical site infections in acute care hospitals: 2014 update. *Infect Control Hosp Epidemiol* 2014;35:605–627.
82. Centers for Disease Control and Prevention. *Surgical site infection (SSI) event*. Atlanta: Centers for Disease Control and Prevention. 2013. <https://www.cdc.gov/nhsn/pdfs/pscmanual/9pscscscurrent.pdf> (last accessed January 13, 2019).
83. Waltz PK, Zuckerbraun BS. Surgical site infections and associated operative characteristics. *Surg Infect* 2017;18:447–450.
84. Centers for Disease Control and Prevention. *Blast injuries. Fact sheets for professionals*. https://cdn.ymaws.com/www.amtrauma.org/resource/resmgr/TIIDE/Blast_InjuryExtremities.pdf (last accessed January 3, 2019).
85. Guermazi A, Hayashi D, Smith SE, Palmer W, Katz JN. Imaging of blast injuries to the lower extremities sustained in the Boston marathon bombing. *Arthritis Care Res (Hoboken)* 2013;65:1893–1898.
86. Church D, Elsayed S, Reid O, Winston B, Lindsay R. Burn wound infections. *Clin Microbiol Rev* 2006;19:403–434.
87. Barki KG, Das A, Dixith S, et al. Electric field based dressing disrupts mixed-species bacterial biofilm infection and restores functional wound healing. *Ann Surg* 2017. DOI:10.1097/SLA.0000000000002504
88. Chaney SB, Ganesh K, Mathew-Steiner S, et al. Histopathological comparisons of *Staphylococcus aureus* and *Pseudomonas aeruginosa* experimental infected porcine burn wounds. *Wound Repair Regen* 2017;25:541–549.
89. Roy S, Elgharably H, Sinha M, et al. Mixed-species biofilm compromises wound healing by disrupting epidermal barrier function. *J Pathol* 2014;233:331–343.
90. Roy S, Santra S, Das A, et al. *Staphylococcus aureus* biofilm infection compromises wound healing by causing deficiencies in granulation tissue collagen. *Ann Surg* 2019. DOI: 10.1097/SLA.0000000000003053.
91. Hawn MT, Vick CC, Richman J, et al. Surgical site infection prevention: time to move beyond the surgical care improvement program. *Ann Surg* 2011;254:494–501.
92. Young PY, Khadaroo RG. Surgical site infections. *Surg Clin N Am* 2014;94:1245–1264.
93. Anderson DJ. Surgical site infections. *Infect Dis Clin N Am* 2011;25:135–153.
94. Garner BH, Anderson DJ. Surgical site infections: an update. *Infect Dis Clin N Am* 2016;30:909–929.
95. Cooper RA. Surgical site infections: epidemiology and microbiological aspects in trauma and orthopaedic surgery. *Int Wound J* 2013;10 Suppl 1:3–8.
96. Gottrup F. Trends in surgical wound healing. *Scand J Surg* 2008;97:220–225.
97. Findley K, Grice EA. The skin microbiome: a focus on pathogens and their association with skin disease. *PLoS Pathog* 2014;10:e1004436.
98. Grice EA. The skin microbiome: potential for novel diagnostic and therapeutic approaches to cutaneous disease. *Semin Cutan Med Surg* 2014;33:98–103.
99. Grice EA, Segre JA. The human microbiome: our second genome. *Annu Rev Genom Hum Genet* 2012;13:151–170.
100. Grice EA, Segre JA. The skin microbiome. *Nat Rev Microbiol* 2011;9:244–253.
101. Misisic AM, Gardner SE, Grice EA. The wound microbiome: modern approaches to examining the role of microorganisms in impaired chronic wound healing. *Adv Wound Care* 2014;3:502–510.
102. Otter JA, Yezli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. *Infect Control Hosp Epidemiol* 2011;32:687–699.
103. Suleyman G, Alangaden G, Bardossy AC. The role of environmental contamination in the transmission of nosocomial pathogens and healthcare-associated infections. *Curr Infect Dis Rep* 2018;20:12.
104. Weber DJ, Rutala WA, Miller MB, Huslage K, Sickbert-Bennett E. Role of hospital surfaces in the transmission of emerging health care-associated pathogens: norovirus, *Clostridium difficile*, and *Acinetobacter* species. *Am J Infect Control* 2010;38(5 Suppl 1):S25–S33.
105. Wille I, Mayr A, Kreidl P, et al. Cross-sectional point prevalence survey to study the environmental contamination of nosocomial pathogens in intensive care units under real-life conditions. *J Hosp Infect* 2018;98:90–95.
106. Yezli S, Barbut F, Otter JA. Surface contamination in operating rooms: a risk for transmission of pathogens? *Surg Infect* 2014;15:694–699.
107. Norbury W, Herndon DN, Tanksley J, Jeschke MG, Finnerty CC. Infection in Burns. *Surg Infect* 2016;17:250–255.
108. Thomas JG, Mantlagh H. Chronic wounds: infectious diseases that won't go away. Wounds, gauzes and biofilms combine for an ugly triad. 2012. <http://healthcare-executive-insight.advanceweb.com/Features/Articles/Chronic-Wounds-Infectious-Diseases-That-Wont-Go-Away-2.aspx#AnchorComment> (last accessed January 13, 2019).
109. Rahim K, Saleha S, Zhu X, Huo L, Basit A, Franco OL. Bacterial contribution in chronicity of wounds. *Microb Ecol* 2017;73:710–721.
110. Cooper RA, Bjarnsholt T, Alhede M. Biofilms in wounds: a review of present knowledge. *J Wound Care* 2014;23:570, 572–574, 576–580 passim.
111. Omar A, Wright JB, Schultz G, Burrell R, Nadworny P. Microbial biofilms and chronic wounds. *Microorganisms* 2017;5:p11: E9.
112. Ganesh K, Sinha M, Mathew-Steiner SS, Das A, Roy S, Sen CK. Chronic wound biofilm model. *Adv Wound Care* 2015;4:382–388.
113. Brown KL, Phillips TJ. Nutrition and wound healing. *Clin Dermatol* 2010;28:432–439.
114. Demling RH. Nutrition, anabolism, and the wound healing process: an overview. *Eplasty* 2009;9:e9–e9.
115. Arnold M, Barbul A. Nutrition and wound healing. *Plast Reconstr Surg* 2006;117(7 Suppl):42 s-58 s.
116. Molnar JA, Vlad LG, Gumus T. Nutrition and chronic wounds: improving clinical outcomes. *Plast Reconstr Surg* 2016;138(3 Suppl):71S–81S.
117. Molnar JA, Underdown MJ, Clark WA. Nutrition and chronic wounds. *Adv Wound Care* 2014;3: 663–681.
118. Patel GK. The role of nutrition in the management of lower extremity wounds. *Int J Low Extrem Wounds* 2005;4:12–22.
119. Brown J. The impact of stress on acute wound healing. *Br J Commun Nurs* 2016;21(Sup12): S16–s22.
120. House SL. Psychological distress and its impact on wound healing: an integrative review. *J Wound Ostomy Continence Nurs* 2015;42:38–41.

121. Lucas VS. Psychological stress and wound healing in humans: what we know. *Wounds* 2011;23:76–83.
122. Vileikyte L. Stress and wound healing. *Clin Dermatol* 2007;25:49–55.
123. Godbout JP, Glaser R. Stress-induced immune dysregulation: implications for wound healing, infectious disease and cancer. *J Neuroimmune Pharmacol* 2006;1:421–427.
124. Glaser R, Kiecolt-Glaser JK. Stress-induced immune dysfunction: implications for health. *Nat Rev Immunol* 2005;5:243–251.
125. Gouin JP, Kiecolt-Glaser JK, Malarkey WB, Glaser R. The influence of anger expression on wound healing. *Brain Behav Immun* 2008;22:699–708.
126. Kiecolt-Glaser JK, Loving TJ, Stowell JR, et al. Hostile marital interactions, proinflammatory cytokine production, and wound healing. *Arch Gen Psychiatry* 2005;62:1377–1384.
127. Wadman M. Scar prevention: the healing touch. *Nature* 2005;436:1079–1080.
128. Bisson JI, Shepherd JP, Dhutia M. Psychological sequelae of facial trauma. *J Trauma* 1997;43:496–500.
129. Prescient Strategic Intelligence. Scar Treatment Market to Reach \$34.9 billion by 2023. 2018. <https://www.psmarketresearch.com/press-release/global-scar-treatment-market> (last accessed January 3, 2019).
130. Ennis WJ. Wound care specialization: the current status and future plans to move wound care into the medical community. *Adv Wound Care* 2012;1:184–188.
131. Yim E, Sinha V, Diaz SI, Kirsner RS, Salgado CJ. Wound healing in US medical school curricula. *Wound Repair Regen* 2014;22:467–472.
132. Patel NP, Granick MS, Kanakaris NK, Giannoudis PV, Werdin F, Rennekampff H-O. Comparison of wound education in medical schools in the United States, United Kingdom, and Germany. *Eplasty* 2008;8:e8–e8.
133. Gottrup F. Education in wound management in Europe with a special focus on the Danish Model. *Adv Wound Care* 2012;1:133–137.
134. Corbett LQ. Wound care nursing: professional issues and opportunities. *Adv Wound Care* 2012;1:189–193.
135. Organization of Wound Care Nurses. <https://woundcarenurses.org> (last accessed January 13, 2019).
136. Hovan H. Improving outcomes through wound care staff education. 2017. <https://www.woundsource.com/blog/improving-outcomes-through-wound-care-staff-education> (last accessed January 13, 2019).
137. Ennis WJ, Lee C, Gellada K, Corbiere TF, Koh TJ. advanced technologies to improve wound healing: electrical stimulation, vibration therapy, and ultrasound-what is the evidence? *Plast Reconstr Surg* 2016;138(3 Suppl):94s–104s.
138. Lindholm C, Searle R. Wound management for the 21st century: combining effectiveness and efficiency. *Int Wound J* 2016;13 Suppl 2:5–15.
139. Yim E, Kirsner RS, Gailey RS, Mandel DW, Chen SC, Tomic-Canic M. Effect of physical therapy on wound healing and quality of life in patients with venous leg ulcers: a systematic review. *JAMA Dermatol* 2015;151:320–327.
140. Gallagher S. Outcome research and WOC nursing practice. *J Wound Ostomy Continence Nurs* 2002;29:278–282.
141. Gray M, Bliss DZ, Bookout K, et al. Evidence-based nursing practice: a primer for the WOC nurse. *J Wound Ostomy Continence Nurs* 2002;29:283–286.
142. Pontieri-Lewis V. Basics of ostomy care. *Med-surg Nurs* 2006;15:199–202.
143. Perry Mayer M, BCh, CCFP. Emphasizing the fundamentals and patient education in diabetic foot care. 2015. <http://www.sawc.net/spring/content/emphasizing-fundamentals-and-patient-education-diabetic-foot-care> (last accessed January 13, 2019).
144. Corbett LQ, Ennis WJ. What do patients want? Patient preference in wound care. *Adv Wound Care* 2014;3:537–543.
145. Aranz. How can patient engagement improve wound care outcomes? 2017. <https://www.aranzmedical.com/uncategorized/outcomes-delivered-patient-engagement-patients-healthcare-providers> (last accessed May 1, 2018).
146. Collins C. Wound care and healing: aiming for zero preventable deaths. 2018. <https://www.defensemianetwork.com/stories/wound-care-and-healing> (last accessed January 5, 2019).
147. Amara JH. Military and veterans' health, health care, and wellbeing. *Defence Peace Econ* 2018;29:1–5.
148. Struve M. TRICARE for life and medicare. 2017. <https://www.gomedigap.com/blog/tricare-for-life-and-medicare> (last accessed December 12, 2018).
149. Liu Y, Sayam S, Shao X, et al. Prevalence of and trends in diabetes among veterans, United States, 2005–2014. *Prev Chronic Dis* 2017;14:E135–E135.
150. Veterans Affairs. VA research on diabetes. https://www.research.va.gov/pubs/docs/va_factsheets/Diabetes.pdf (last accessed January 3, 2019).
151. Franklin H, Rajan M, Tseng CL, Pogach L, Sinha A, Mph M. Cost of lower-limb amputation in U.S. veterans with diabetes using health services data in fiscal years 2004 and 2010. *J Rehabil Res Dev* 2014;51:1325–1330.
152. USAMRMC. Combat Casualty Care Research Program (CCCRP). https://mrmc.amedd.army.mil/index.cfm?pageid=medical_r_and_d.ccc.overview (last accessed December 12, 2018).
153. Rose LF, Wolf EJ, Brindle T, et al. The convergence of regenerative medicine and rehabilitation: federal perspectives. *NPJ Regen Med* 2018;3:19–19.

Abbreviations and Acronyms

BMI	=	body mass index
DFU	=	diabetic foot ulcer
DoD	=	Department of Defense
FU	=	foot ulcer
IGB	=	intra-gastric balloon
PNI	=	psychoneuroimmunology
PU	=	pressure ulcer
QoL	=	quality of life
SSI	=	surgical site infection
T2D	=	type 2 diabetes
VA	=	Veterans Affairs
WHO	=	World Health Organization