

REVIEW

Skin integrity, antimicrobial stewardship and infection control: a critical review of current best practice

Joanna Blackburn^{*1}, Zlatko Kopecki², Karen J Ousey^{3*}

¹Institute for Skin Integrity and Infection Prevention, Department of Nursing and Midwifery, University of Huddersfield, UK.

²Future Industries Institute, University of South Australia, Australia.

³Institute for Skin Integrity and Infection Prevention, Department of Nursing and Midwifery, University of Huddersfield, UK.

*Corresponding author email J.Blackburn3@hud.ac.uk

Abstract

'Skin integrity' refers to intact, unbroken, and healthy skin. Disruption of skin integrity can be caused by intrinsic and extrinsic factors including altered nutritional status, vascular disease, diabetes, and tissue injury, and this is often associated with development of localised clinical infection. Skin health and hygiene is important for preventing wounds and development of localised clinical infection or sepsis. Clinical wound infection is an increasing problem in healthcare, with the potential for increasing the burden of antimicrobial resistance (AMR), if antimicrobials are overused to treat wound infection.

In this review we discuss skin integrity and wound infection prevention and outline the guiding principles of antimicrobial resistance and antimicrobial stewardship for infection control. Additionally, we provide a critical review of current best practice, highlighting the pathway to guide management of patients at risk of infection development, and discuss the latest research progress on antimicrobial resistance and skin integrity.

Keywords antimicrobial stewardship, infection control, skin integrity

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Introduction

Optimal skin health is crucial for protecting the body against disease and infection, as well as serving to regulate body temperature and preventing damage to the internal organs. Skin integrity has been defined by the Department of Health, Australia,¹ as the skin being "whole, intact and undamaged", maintenance of skin integrity can be disrupted through processes such as natural aging² or from extrinsic factors including external damage, trauma, or infection.^{3,4} Impaired skin integrity occurs when the body fails to protect itself. Defined by the North American Nursing Diagnosis Association⁵ as an "altered epidermis and/or dermis, destruction of skin layers (dermis) and disruption of skin surface (epidermis)," impaired skin integrity can occur in response to, or be caused by, infection and inflammation, which can lead to complications such as disease, skin tears and pressure damage.^{2,3} Clinical wound infection is an increasing problem in healthcare, with the potential for increasing the burden of antimicrobial resistance (AMR) if antimicrobials are overused to treat wound infection. Appropriate treatment and management of wound infection

and ensuring the appropriate prescribing of antibiotics is crucial to limiting the spread of AMR. Antimicrobial Stewardship (AMS) is a coordinated approach to ensuring the appropriate use of antimicrobials (including antibiotics) to improve patient outcomes, and includes strategies such as raising awareness of AMR and appropriate antimicrobial prescribing. AMS is one way of reducing the problem of AMR in healthcare.

Skin integrity and wound infection prevention

The Wounds UK Best Practice Statement on Maintaining Skin Integrity⁶ highlights who is most at risk of complications from skin damage. The list includes older people and patients suffering from long-term conditions.⁶ Several inflammatory, autoimmune and genetic skin conditions, such as eczema, psoriasis and dermatitis, which affect the skin's ability to act as a barrier against infection also predispose people to compromised skin integrity.⁶

Although some patients maybe be predisposed to developing complications due to impaired skin integrity, it

is the responsibility of health care professionals to ensure all patients have an adequate holistic skin assessment to help prevent breakdowns in skin function.⁷ Skin assessments can help to identify potential risks to the patient and prevent skin damage occurring or escalating, as well as providing an opportunity to implement appropriate treatment strategies, if necessary. A holistic approach to help prevent breakdowns in skin function should include gathering details of the patients' medical history, including overall health, mobility, and nutrition.⁸ Appropriate training and education on the risk factors of impaired skin integrity and undertaking skin assessments are vital to the prevention of wound development.⁹ The Wounds UK Best Practice Statement on Maintaining Skin Integrity⁶ presents the following elements that should be included in a comprehensive skin assessment:

- Patient medical history,
- Assessment of skin condition, texture and temperature,
- Assessment of intrinsic or wound related factors,
- Assessment of patient's knowledge about their skin condition, and 4) history of the skin condition.⁶

Most common skin conditions that affect the skin integrity may include following: rash (irritation or medically induced), inflammatory skin conditions (such as eczema, psoriasis), genetic conditions (such as ichthyosis, epidermolysis bullosa), pruritus, cellulitis, skin cancer (such as melanoma, squamous cell carcinoma), lipodermatosclerosis.⁶ Patients at high risk of disrupted skin integrity and associated skin changes are outlined in Table 1.

Skin health and good skin hygiene are important for preventing wounds and development of localised clinical infection or sepsis. Clinical wound infection has been defined by the Wound Infection Institute¹⁰ as "the invasion of a wound by proliferating microorganisms to a level that invokes a local and/or systemic response in the host". Clinical wound infection has been highlighted as an increasingly emerging medical problem with profound impacts on the healthcare system, with the potential for severe and enduring complications for patients and associated financial burdens, if early identification and appropriate treatment interventions are not implemented promptly. The IWII Wound Infection Continuum (WIC)¹⁰ demonstrates the phases of wound infection through five stages from contamination to systemic infection and describes the symptoms associated with each phase (Figure 1). Factors it claims are associated with increased risk of infection include:

- Host risk factors, such as chronic diseases like diabetes, peripheral neuropathy, radiation or chemotherapy, immune system problems and connective tissue disorders, malnutrition, obesity, and alcohol and drug abuse;
- Wound risk factors (chronicity, duration, type of injury, anatomical location, foreign body presence or necrotic tissue, increased oedema, impaired perfusion, deep tissue involvement); and
- Environmental factors, such as an unhygienic environment, hospitalisation, inadequate moisture management, and interface pressure.

Table 1. Patient groups at high risk of disrupted skin integrity, associated skin changes and potential outcomes. Reproduced with permission from The Wounds UK Best Practice Statement on Maintaining Skin Integrity.⁶

Patient group	Skin changes	Outcomes
Older adults	Thinner less elastic skin, reduced circulation and subcutaneous fat, decreased skin hydration	Skin tears, pressure ulcers, infection, inflammation, dryness, cellulitis
Spinal cord injury	Altered vascular supply, temperature control, maceration, loss of collagen and muscle mass, impaired sensation	Skin tears, pressure damage, infection, inflammation
Critically ill and injured children (e.g. children with genetic diseases like ichthyosis (dry skin) or epidermolysis bullosa (skin blistering disease))	Intrinsic changes, shear and friction, poor perfusion and maceration	Nappy dermatitis, skin tears, pressure damage, impaired healing, infection
Patients with spina bifida and cerebral palsy	Decreased perfusion, skin reaction to drugs, perineal dermatitis and inflammation due to incontinence	Pressure damage
Bariatric patients	Altered epidermal cells, increased water loss, dry skin, maceration, increased temperature, reduced lymphatic flow and perfusion	Pressure damage, skin tears, diabetic ulcers, psoriasis, moisture lesions, impaired healing, infection
Oncology patients	Radiation-induced epidermal damage and inflammation, decreased perfusion	Pressure damage, impaired healing, infection and cellulitis

While many sample tools have been developed to assess the risk of infection many are validated against certain wound types, dependent on numerous risk variables, and have low to moderate predictive power. Hence, the expertise of the healthcare professional is relied upon to diagnose critical colonisation early, before localised clinical infection develops.

Antimicrobials is a general term for a set of treatments designed to reduce infection. It can include antibiotics, antiseptics, antivirals, antifungals and anti-parasitic.¹¹ Antimicrobial Resistance (AMR) occurs when microorganisms, through repeated exposure to medicines, develop a resistance and no longer respond to antimicrobial treatments, even at high concentrations.¹¹ Infections that develop resistance to commonly available antimicrobials become harder to treat and increase the risk and spread localised wound infection to sepsis. AMR has a significant impact on the public, patients, and healthcare system.¹¹ Antimicrobial resistant bacteria increase the risk of disease and mortality and increase healthcare costs, due to longer hospital stays and treatment. Furthermore, it is estimated that over 5 million deaths worldwide each year are due to AMR¹¹ and this figure is expected to increase over time.

Antimicrobial resistance (AMR) and antimicrobial stewardship (AMS)

Studies to date have shown that AMR can be accelerated by: the overuse and misuse of antibiotics in humans and animals; health care transmission; environmental contamination; and suboptimal vaccination. A lack of newly available antibiotics to treat infections also significantly increased the risk of serious illness and death in the community.¹² To address the problem of AMR, the World Health Organization (WHO)¹³ developed the Global Action Plan (GAP) which outlines the global priorities for tackling AMR and focuses on five main strategic objectives:

- Improving AMR awareness and understanding
- Strengthening knowledge through AMR surveillance and research
- Reducing the incidence of clinical infection
- Optimising the use of antimicrobial medicines
- Ensuring sustainable investment in tackling AMR

Central to the GAP is AMS; a coordinated approach to ensuring the appropriate use of antimicrobials (including antibiotics) to improve patient outcomes, reduce AMR, and

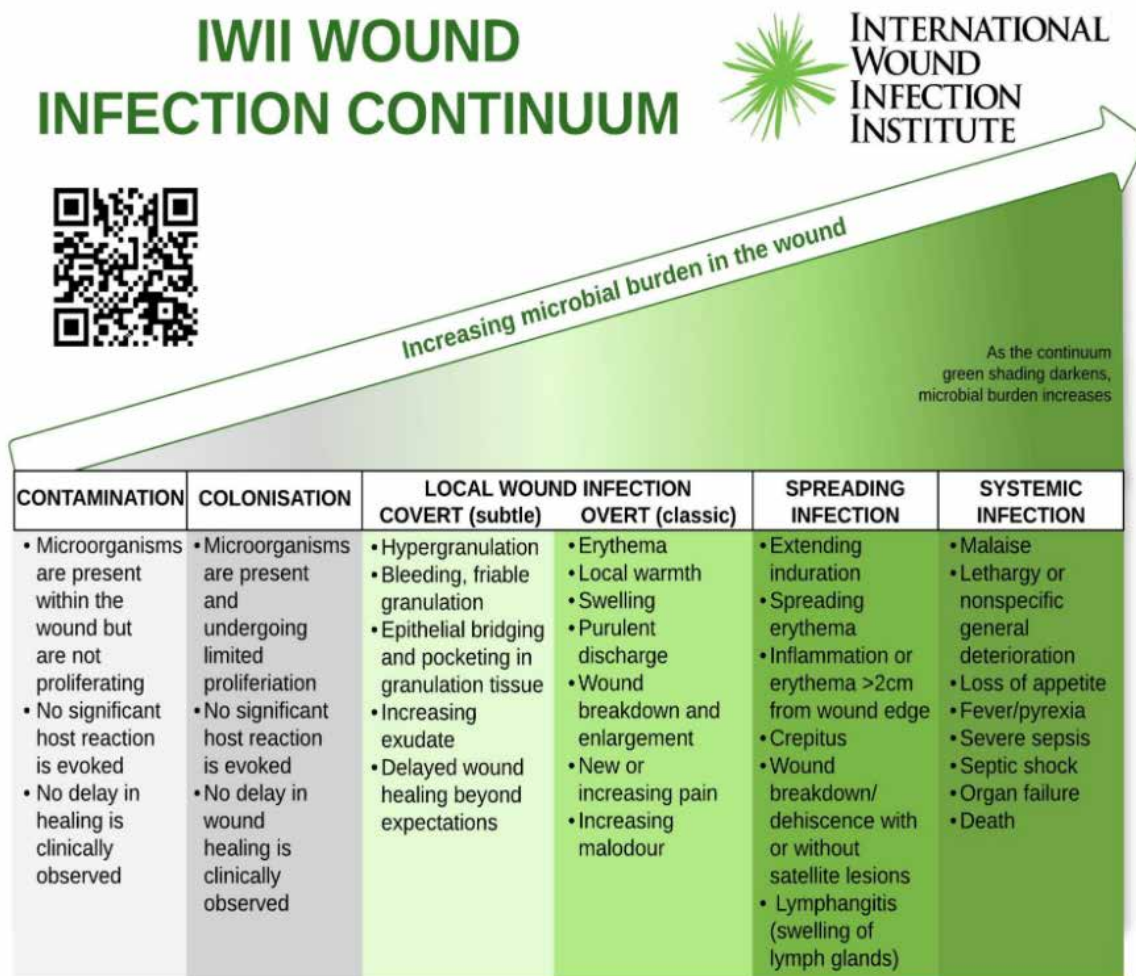


Figure 1. International Wound Infection Institute (IWII) Wound infection Continuum (IWII-WIC). Reproduced with permission from IWII¹⁰

decrease the spread of infections caused by multidrug-resistant organisms. AMS and infection control are critical elements of healthcare practices aimed at promoting the effective use of antimicrobial agents to treat infections. AMS has been defined by several healthcare organisations focused on education about the treatment of infectious diseases and infection prevention to limit the burden and spread of AMR. The National Institute for Care and Health Excellence (NICE) defines AMS as “an organisational or healthcare-system-wide approach to promoting and monitoring judicious use of antimicrobials to preserve their future effectiveness”.¹⁴ While WHO defines AMS as “a coherent set of integrated actions, which promote the response and appropriate use of antimicrobials to help improve patient outcomes across the continuum of care”.¹⁵ WHO also has a distinct definition of an AMS program which is “an organisational or system-wide health-care strategy to promote appropriate use of antimicrobials through the implementation of evidence-based interventions”.¹⁵ The GAP is also supported by the WHO Global Framework for the Development and Stewardship to Combat AMR,¹⁶ which aims to provide a set of evidence-based recommendations to drive integrated AMS activities within organisations, to preserve antimicrobials. Central to this is the integration of infection control measures, such as appropriate hand hygiene measures and access to clean water (particularly in low to middle income countries) which can minimise the emergence and spread of AMR.¹⁶

The guiding principles of the World Health Organization (WHO) policy¹⁵ for integrated AMS activities are:

- Give due consideration to national and local context and the structure of the health system in carrying out AMS activities.
- Focus on prioritising implementation of activities that are likely to provide the greatest benefits based on national and facility needs assessment.
- Strengthen and use existing national and subnational platforms and coordinating mechanisms and resources to implement integrated AMS activities.
- Ensure strong and effective linkages and synergies between relevant areas and disciplines related to AMR, including national infectious diseases and infection prevention programmes.

AMS and wound care

The Wounds UK Best Practice Statement on AMS for wound management¹⁷ describes the important role AMS can play in maintaining good skin integrity and provides useful advice on infection prevention practices. The multimodal approach¹⁷ to antimicrobial stewardship (AMS) practice is underpinned by good education including:

- Increased public awareness, implementing changes to local and processes and systems;
- Having good knowledge of multidisciplinary teams;

- Accurate assessment of clinical signs and symptoms of infection;
- Minimising the use of unnecessary broad spectrum antibiotics;
- Use of dressings with a physical mode of action, which act to bind bacteria and fungi, in conjunction with antiseptics and topical agents for wound care; and
- Understanding the responsibilities and expectations of patient self-care.

The foundation of infection prevention in wound care should focus on a back-to-basics approach of good hand hygiene, use of personal protective equipment, good waste management, comprehensive documentation, and management of the patient’s environment.

Table 2 provides a detailed summary describing the infection protection and AMS practice in wound care as outlined below:

Several barriers to implementing effective antimicrobial stewardship (AMS) strategies have been identified in the literature. For example, Limato et al,¹⁸ found that healthcare professionals (including microbiologists, pharmacists, physicians, surgeons, and hospital managers) described how ineffective resources, competing priorities and insufficient medical facilities prevented AMS strategies from being effective. Other research highlighted that although awareness of AMS in wound care has been found to be high, the measurement of the impact of AMS programs or strategies is low,¹⁹ therefore increasing education around how AMS activities can be measured is an important aspect of reducing the impact of AMR in healthcare.

The International Wound Infection Institute (IWII) Wound Infection in Clinical Practice consensus document¹⁰ states that AMS activities should center around education on appropriate prescribing and monitoring the use of antimicrobial usage. At an individual level, this could involve better education of patients and caregivers surrounding signs of infection, the importance of adherence to treatments and medications, when to seek medical attention, and on suitable alternatives to the inappropriate use of antimicrobials. At a system level, this could involve ongoing healthcare professional education and regular auditing of antimicrobial prescribing.¹⁰ The IWII also recommends establishing an AMS advisory group to guide and monitor antimicrobial use, including antibiotic practices within organisations to drive change and improvements in current practice and limit the use of unnecessary prescribing. This is important, since evidence from the UK demonstrates a significant amount of antibiotic prescribing occurs in primary care with approximately 20% of antibiotics being prescribed inappropriately.²⁰ Alarmingly, that figure was even higher in Australia where 33–73% of prescriptions in primary care were not appropriately prescribed, compared to 23% in hospitals,²¹ with level of experience, use of AMR guidelines and clinical setting

Table 2. Summary of infection prevention and AMS practice considerations. Reproduced with permission.¹⁷

Patient and wound	Environment	Healthcare professionals and carers	Protocols
Avoid any break in the skin and preserve overall skin integrity (i.e. keep skin clean, dry and well hydrated) according to local policy and international guidance (LeBlanc et al, 2018) ⁸	Clean/disinfect all surfaces before use and reduce clutter (e.g. ensuring appropriate storage spaces for equipment and dressings)	Hand hygiene is critical in wound management and prevention of infection	Prevent cross-infection by implementing universal precautions and aseptic techniques
Implement wound bed preparation to reduce wound or skin microbial load: <ul style="list-style-type: none"> - Debride the wound of necrotic tissue, debris, foreign bodies, wound dressing remnants and slough - Cleanse the wound at each dressing change - Use aseptic technique for acute wounds and a clean technique for chronic ulcer 	Use appropriate waste disposal facilities for unused antimicrobial therapy and dressings and materials that may harbour antimicrobial resistant bacteria	Adhere to uniform policy. For example, avoid the following: <ul style="list-style-type: none"> - False nails/gel nails (dirt behind long nails is an infection risk) - Jewellery (apart from a wedding band and stud earrings) - False eyelashes - Wearing hair down (touching or below the collar) - Fitness tracking watches or devices 	Work to reduce/manage exposure of dressings/ bandages to urine, faeces or other contaminants (use barrier cream where necessary)
Optimise management of comorbidities (e.g. diabetes, tissue perfusion/oxygenation), nutritional status and hydration	Provide adequate lighting	Asses staff with skin conditions on an individual basis to see if they should be working or require extra PPE	Avoid 'double dipping' in larger pots of creams and ointments
If the patient is at considerable risk, decontamination measures should be considered (e.g. cleaning and waste disposal), and in some cases, isolation may be considered	In the patient's home: Consider the impact of any pets in the home environment (i.e. keeping pets away from the wound and ensuring general hygiene is always maintained)	Staff illness: Staff should be encouraged to stay at home if there is an infection risk.	Improve documentation of infection and remember that AMS is everyone's responsibility throughout the patient journey
Patient's capacity for self-care should be established in the home setting, education about hygiene may be needed (e.g. how to apply creams without increasing infection risk, suitable bathing products, how to dry patient skin with a clean towel)		Training for new staff to ensure that all staff have up-to-date training for local protocols	Routine review of antibiotics and antimicrobials including review of local policies and procedures
Consider antimicrobial treatment in some instances, such as suspected diabetic foot infections (NICE, 2019) ¹⁴ and suspected surgical site infections (NICE, 2019) ¹⁴			Store equipment and supplies appropriately

being the biggest driving factors in antibiotic prescribing.²² The integration and monitoring of AMS strategies at all organisational levels is necessary for AMS activities to drive change in antibiotic prescribing in wound care.²³ Health care professionals are expertly placed to advance change in their own practices and provide education to patients on AMR, as insufficient knowledge has been found to drive inappropriate prescribing worldwide.²⁴ A multidisciplinary collaborative approach with experts in wound care, including tissue viability nurses, wound nurse practitioners, podiatrists and community nurses having input into AMS strategies is highly recommended.²⁵ Edward-Jones²⁶ described the importance of AMS education for those working in wound care and advocated for exploration of other methods of wound care rather than simply prescribing antibiotics, with topical antiseptics being one proven method of reducing the impact of AMR.²⁶

AMS and antiseptics

The WHO Access, Watch, Reserve (AWaRe)¹¹ antibiotic guidance document defines antibiotics as “antimicrobial products used to slow or stop the growth of microorganisms”. In the vast majority of cases, antibiotics are not necessary, despite a significant proportion of patients who present in primary care with an infection still being prescribed them.²⁷ The international consensus document on the use of wound antiseptics in clinical practice²⁸ provides an overview on the potential benefits of using antiseptics to prevent and treat wound infection, alongside practical guidance on how to use them safely and effectively in a clinical practice. This document states that antiseptics are grossly underutilised as a method of infection management²⁹ and that they are an effective alternative to antimicrobials.^{30,31} Topical antiseptics commonly used in wound management can include wound dressings, lotions, and cleansers.²⁸ Choosing the right antiseptic for the patient is crucial to avoid causing unnecessary problems, including additional skin irritation.³²

Consistently, Blackburn et al³⁴ explored the effects of using topical antimicrobials on AMR and found that there was very limited evidence to prove efficacy, with most clinical evidence focusing on exploring the effectiveness of topical antimicrobials on infection and subsequent wound healing. The authors suggested that understanding the contribution of topical antimicrobials in AMR remains an important issue that is yet to be fully investigated.

Antimicrobial wound treatments

Antimicrobial wound treatment should be guided by a holistic wound assessment and identification of the infection causing micro-organisms to ensure appropriate treatment is prescribed; that it is specific to the wound infection; and that it is only prescribed for a limited period of time.^{25,33} The expertise of the treating clinician is critical to recognise whether a clinical assessment reveals that a wound is clinically infected, and that topical antimicrobial agents or wound dressings should not be used as a form of treatment.²⁸

Wound infection diagnosis should be based on a clinical diagnosis supported by microbiological findings.³⁵ The Wounds UK Best Practice Statement on AMS strategies for wound management refers to the ‘five rights’ of drug administration which have been modified for appropriate prescribing of antibiotics in wound care.¹⁷ The five rights emphasise the importance of appropriate identification and treatment strategies to ensure the most appropriate antimicrobial is administered promptly, at the right dose and for the optimal length of time to treat the infection. The five rights are the:

- Right diagnosis and care plan
- Right antimicrobial and the right delivery system
- Right time to initiate antimicrobial treatment
- Right antimicrobial dose
- Right duration of antimicrobial treatment

AMS and sepsis

WHO¹² defines sepsis as a life-threatening condition due to the body’s response to infection. Sepsis is unfortunately a frequent consequence of many infectious diseases (including wound infections) and can result in organ failure and death.¹² It is particularly common in older adults and in those with immunosuppressive disorders. Sepsis is common in the aging population, and it disproportionately affects patients with cancer and underlying immunosuppression. Septic shock occurs when this response results in impaired blood supply to organs requiring specific treatments to maintain adequate perfusion.^{36,37} There are approximately 48.9 million cases and 11 million sepsis-related deaths worldwide, accounting for an estimated 20% of all global deaths.³⁸ An estimated 918,000 people in the UK have sepsis each year, with around 48,000 deaths.³⁹ AMR poses a significant challenge to the treatment of sepsis; the UK Sepsis Trust states that sepsis claims more lives than some of the most severe types of cancers⁴⁰ and that an estimated 5% of emergency admissions are due to sepsis. Approximately 70% of cases of sepsis occur in primary care.⁴¹ Additionally, despite the importance of early medical attention and excessive costs of sepsis to the Australian healthcare system (direct costs of \$700 million, and indirect costs of \$4 billion) the community awareness of sepsis is extremely low.⁴² As antibiotics form the initial treatment strategy for sepsis, ensuring wounds are properly managed is key to managing infection and limiting wound deterioration. The decision to prescribe antibiotics for sepsis management is often a clinical decision and while AMS and sepsis management coincide, following local sepsis guidelines can help minimise the impact of AMR, while maximising wound healing and patient outcomes. This further highlights the importance of an appropriate AMS strategy in relation to management of skin and wound infections. Figure 2 outlines the pathway to guide management of patients with wounds, with or without infection risk, considering the principles of antimicrobial stewardship.¹⁷

Current research on AMR and skin integrity

Research is essential for guiding practice to address AMR and can help further our knowledge on improving wound infection diagnosis and treatment. WHO³⁶ published the first global research agenda for AMR in human health, highlighting the research priorities required to inform policy and practice, spanning 11 AMR areas of concern, across five themes to include prevention, diagnosis, treatment and care, cross-cutting and drug-resistant TB. This was in part due to the fact that limited progress has been made on raising awareness of AMR and AMS since the introduction of the GAP.⁴³ Furthermore, in a recent systematic review exploring the interventions used to implement antimicrobial stewardship practices among hospitalised patients in least-developed countries, Mzumara et al⁴⁴ concluded that measuring a range of outcomes including prescribing, patient, and microbiological outcomes, are all crucial to adequately evaluate the effectiveness of AMS interventions in wound care.⁴⁴ The current literature suggests varying levels of inappropriate prescribing of antibiotics in both inpatient and outpatient settings with some studies reporting

figures as high as 50%^{45, 46} and 20% in UK primary care,⁴⁷ double the levels reported for parts of Scandinavia and the Netherlands.⁴⁸ This problem is further reinforced by the British Society for Antimicrobial Chemotherapy (BSAC) and European Wound Management Association (EWMA) position paper²⁵ stating that AMS is fundamental to promoting the appropriate use of antimicrobials, including antibiotics, and in reducing AMR.^{25,33} Given that wound management accounts for 16.4% of all systemic antibiotic prescriptions¹⁸ varying levels of clinical knowledge have been shown to further contribute to the inconsistent use of antimicrobials.⁴⁸ Improving professional education, particularly around furthering clinician understanding of the need for more sustainable use of antibiotics is, therefore, a core focus of the UK Department of Health's 2019-2024 five-year antimicrobial stewardship strategy,⁴⁹ which suggested that such education should be supported by current policies and local guidelines²⁵ and by the development of local standardised measurements to document patient wound care status and care planning. Likewise, the Australian Government released a 20-year vision and strategy document called Australia's National

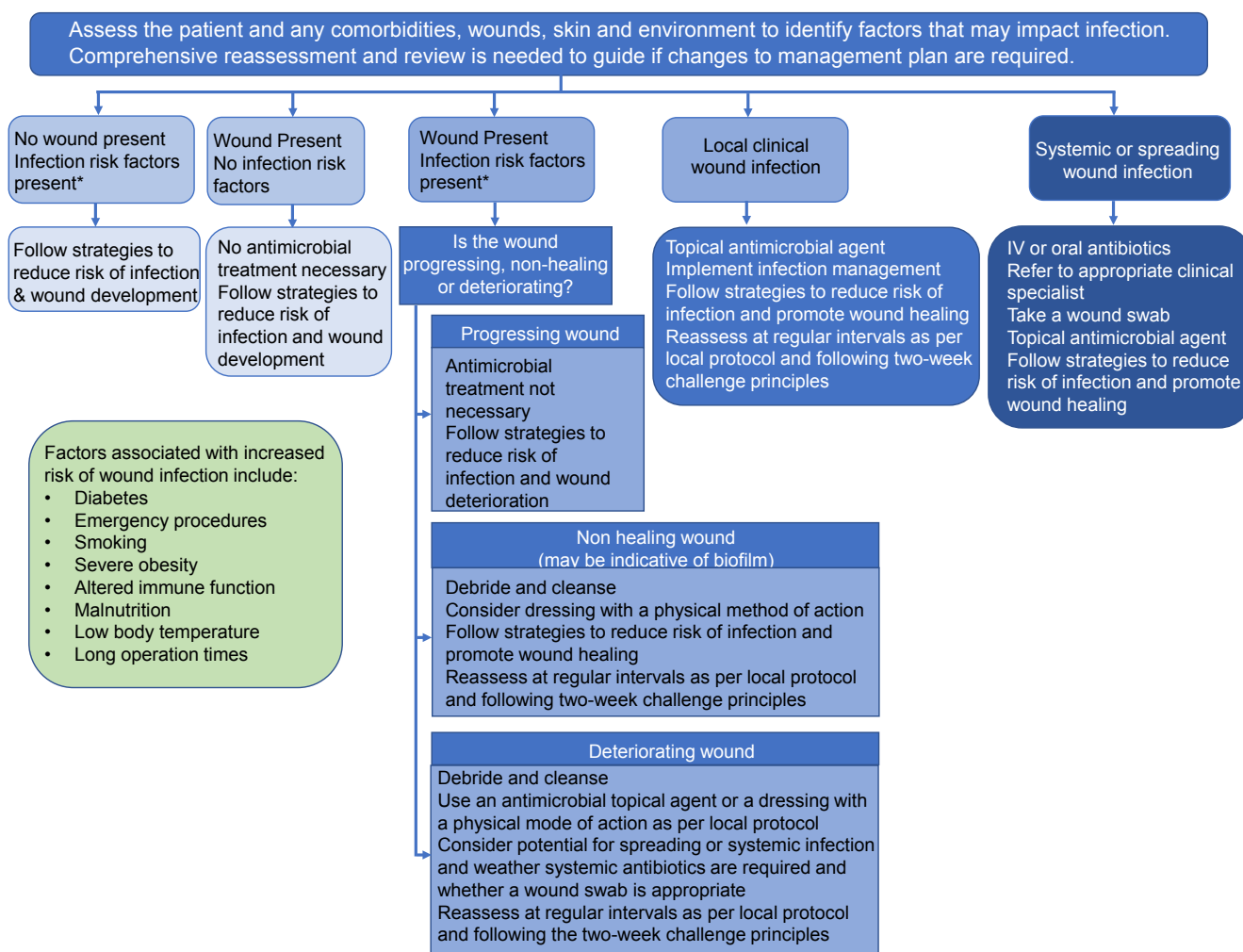


Figure 2. Pathway to guide the management of patients with wounds with or without infection considering the principles of antimicrobial stewardship. IV = intravenous. Figure reproduced with permission from Wounds UK ¹⁷ Best Practice Statement: Antimicrobial stewardship strategies for wound management. Wounds UK, London.

Antimicrobial Resistance Strategy 2020 and Beyond.⁴⁹ It supported seven key objectives aimed at tackling AMR:

- Clear governance for AMR Initiatives;
- Prevention and control of infection and the spread of resistance;
- Greater engagement in the combat against resistance;
- Appropriate usage and stewardship practices;
- Integrated surveillance and response to resistance and usage;
- A strong collaborative research agenda across all sectors; and
- Strengthening global collaboration and partnerships.

Prioritising action in developing a collaborative research agenda will facilitate a flexible AMR research agenda that aims for innovation, coordination, shared research and development activities, as well as dedicated funding for a national research agenda and support for translation of research findings into new approaches, application and policies that combat AMR.⁴⁹

From a prescribing perspective, over-cautious decision making can contribute to the problem of AMR, something which was particularly evident during the COVID-19 pandemic in the UK, which resulted in an increase of antibiotic prescribing (up 6.71%) despite a reduction in face-to-face GP appointments (reduction of 51.5%) and an increase in telephone appointments (increase of 270.45%).⁵⁰

Although AMS is an important strategy for managing the problem of AMR, evidence suggests that many AMS interventions do not accurately measure or assess their impact; for example, in a pilot survey of nurses attending a webinar on AMS, Ousey et al³⁵ explored the effectiveness and impact of AMS programmes. A total of 987 nurses completed the survey (including advanced nurse practitioners; wound care specialists; podiatrists; tissue viability specialists; and wound, ostomy and continence nurses). The results showed that although many participants were completely, or partially aware of AMS (35.1% and 57.9% respectively), with most having an AMS strategy within their practice, almost 65% of participants (64.3%) stated that they did not measure the impact their AMS strategy. This means it is difficult for them to accurately determine the effectiveness of their AMS programme in managing AMR outcomes.³⁵ In 2023 The Australian Commission on Safety and Quality in Health Care released a report called Antimicrobial Use and Resistance in Australia Surveillance System (AURA). It looked at antimicrobial resistance in human health and noted that the most common indications for antimicrobial prescriptions in aged care include non-surgical wound infections. This was the fourth most common indication for number of prescriptions issued.⁵¹ Alarmingly, the report found that 31.3% of hospital prescriptions for non-surgical wounds and 22.5% for wound infection were not compliant

with guidelines for antimicrobial use in Australian hospitals.⁵¹

In the context of wound management, there remains a clear lack of knowledge surrounding the role of biofilms in non-healing wounds with a tendency to adopt *in-vitro* based models for how bacteria grow in non-healing wounds. Current research is, therefore, focused on gaining a better understanding to bridge the preclinical findings into clinical applications. Additionally, there is a continued evaluation and research focus on timely diagnosis of wound infection using technologies such as infrared and digital imaging. Preliminary research surrounding Dynamic Infrared Thermography (DIRT) had demonstrated that perforator mapping using DIRT could be a potentially valuable tool for stratification of high-risk patients in evidence-based antibiotic prophylaxis⁵² while fluorescent imaging tools have been shown to be useful in early detection of bacterial colonisation of wounds and dermal templates.⁵³ Additionally, a number of studies have focused on developing wound dressings using smart biomaterials that can deliver antimicrobials in response to changes in wound pH and temperature in a stimuli-responsive manner to both reduce associated toxicity to mammalian cells and decrease AMR development.^{54,55} Research has also focused on practical assessment of antimicrobial dressings evaluating their efficacy during storage and after opening to better understand their effects on AMR development and cost-effectiveness, while preserving clinical efficacy and safety.⁵⁶ In the context of skin integrity, researchers are continuously generating and implementing evidence-based wound care tools, educational resources, including best practice statements, and skin integrity prevention models to facilitate clinical translation and uptake of evidence-based practice.^{57,58,59, 60} Lastly, researchers and clinicians are also exploring standardisation of methods to calculate effectiveness of antimicrobial dressings against both planktonic and biofilm bacteria, and microbial communities associated with wounds.⁶¹ Probst et al³³ highlighted that the primary endpoint should be defined either as prevention of clinical infection or clinical resolution of infection when choosing a topical antimicrobial treatment for wound care and that researchers should adhere to standard research guidelines to support improved uniformity and comparability of clinical studies.

Conclusions

Strategies to tackle the global crisis of AMR include implementation of AMS strategies across healthcare settings, including in clinical wound management, with a focus on maintaining skin integrity. Educational strategies play a critical part in raising awareness of AMR in wound management to support wound care practitioners and facilitate better understanding and implementation of AMS programs in clinical practice. This is critical to the maintenance of skin integrity and tackling the global challenges of wound infection.

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Conflict of interest

The authors declare no conflicts of interest.

Ethics statement

An ethics statement is not applicable.

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Author contribution

All authors contributed equally to writing and editing of the manuscript, approve the final submission and share responsibility for integrity of the work.

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