An overview of the prevention and management of wound infection

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Abstract
A wound can be defined as infected when the presence and subsequent proliferation of microorganisms leads to a local or systemic response in an individual. Wound infection is associated with delayed healing, wound chronicity, increased risk of hospital admission, loss of limb or digit and increased healthcare costs. The presence of biofilm is also recognised as a challenge in infected wounds and is associated with chronicity and delays in healing. Identifying and managing wound infection early can contribute to faster wound healing, thus reducing the risk of negative outcomes. This article details the pathophysiology, risk factors and signs and symptoms of wound infection. It also outlines various prevention and management options for wound infection.

Aims and intended learning outcomes
The aim of this article is to enable nurses who are responsible for managing wounds to recognise the risk and occurrence of wound infection and to understand how to prevent and manage it effectively. After reading this article and completing the time out activities you should be able to:
» Recognise the differences between acute and chronic wounds.
» Understand the pathophysiology of wound infection.
» Describe the signs and symptoms of wound infection.
» Identify the factors that can increase the risk of infection.
» Outline the various prevention and management options for wound infection, while considering the importance of antimicrobial stewardship.

Introduction
A wound is defined as any break in the continuity of the skin (Vuolo 2009). There are several different wound types as shown in Box 1, all of which carry a risk of developing an infection.

Wounds are commonly categorised as acute or chronic (Box 2). A chronic wound has been defined as ‘a wound that makes slow progression through the healing phases or displays delayed, interrupted or stalled healing’ (International Wound Infection Institute 2022). An acute wound has been defined as ‘a wound with an aetiology that occurs suddenly, either with or without intention, but then heals in

Box 1. Examples of different wound types
» Surgical wounds
» Traumatic injuries
» Pressure ulcers
» Leg ulcers (venous, arterial or mixed)
» Foot ulcers (diabetes mellitus-related or other)
» Fungating or malignant wounds
» Burns
» Dermatological or inflammatory wounds
(Price et al 2022)
a timely manner’ (International Wound Infection Institute 2016). It can be useful to understand the difference between acute and chronic wounds to manage healing expectations and support care planning. However, it is important to remember that an acute wound can become chronic if healing is delayed.

While both acute and chronic wounds can sustain an infection, it is more likely to occur and delay healing in chronic wounds (Guest et al 2020). Of the estimated 3.8 million people to have a wound managed by the NHS in 2017/2018, 40% had a documented infection; this is higher in chronic wounds such as diabetic foot ulcers (78%) and lower in acute wounds (excluding surgical wounds) (24%) (Guest et al 2020). Surgical site infection can lead to complications such as dehiscence (any degree of separation of the margins of a closed surgical wound) and readmission (Guest et al 2018, World Union of Wound Healing Societies 2018).

Most wound care is delivered by nurses, so they have a central role in identifying and managing wound infection. Preventing wound infection is often a multidisciplinary team function and it is important that nurses and other healthcare practitioners involved in managing wounds, as well as the patient themselves, are aware of prevention measures.

### Pathophysiology of wound infection

For a wound to become infected, a microbe that can enter the wound and overwhelm the individual’s (host’s) defence is required. Preventing infection relies on breaking the chain of infection before contamination of the wound (Shaw 2016). Microbes infecting a wound are commonly planktonic bacteria, which are singular microbes that free-float and attach to a surface or each other (International Wound Infection Institute 2022). If microbes contaminate the wound, then the individual’s immune response, effective wound hygiene, cleansing and appropriate dressing selection may prevent them colonising and causing a local infection. If a local wound infection develops and is not treated successfully, the infection can spread systemically and could lead to sepsis. At this point the microbe is referred to as pathogenic – that is, the microbe that is causing the infection. Infections can be contaminated or colonised with microbes without stimulating a host reaction or wound infection (International Wound Infection Institute 2022). If a wound or host reaction occurs, then the wound is defined as infected. Wound infection is described as a continuum (Figure 1).

**Presence of biofilm**

Once planktonic bacteria attach, they can develop further into microcolonies and form a stronger attachment to the wound surface and each other (Cooper et al 2014). An extracellular polymeric substance is secreted by these colonies and surrounds the colonies, which continue to grow taller within this matrix (Cooper et al 2014). This is known as biofilm. As this growth continues, the environment for the biofilm may become competitive, and at this point planktonic bacteria will be seeded to attach elsewhere (International Wound Infection Institute 2016). It is understood that planktonic pathogens, particularly those that are yet to fully attach, are easier to eradicate using antimicrobials than those that have formed biofilm (International Wound Infection Institute 2016). Biofilm has tolerance for antimicrobials and the individual’s natural immune response can be ineffective against biofilm, rendering usual infection management strategies ineffectual (Cooper et al 2014).

Less than 10% of acute wounds are believed to contain biofilm (Clinton and Carter 2015), but in chronic wounds it could be present in as much as 78% (Malone et al 2017). Therefore, biofilm can contribute to wound chronicity, while wound chronicity is more likely to be associated with biofilm. Visually recognising biofilm in a wound is challenging, if not impossible (Schultz et al 2017). Non-healing and chronicity could be suggestive of the presence of biofilm (International Wound Infection Institute 2016, Wounds UK 2017). While the presence of slough – a collection of devitalised tissue or senescent cells and a yellow or brown appearance – in itself does not necessarily indicate biofilm, it is likely that biofilm is present in a sloughy wound (Wounds UK 2017). Thus, removing the slough can be useful to reduce or remove biofilm (Wounds UK 2017). Figure 2 shows a sloughy leg ulcer that may have biofilm present.

### Factors that increase the risk of wound infection

Anyone with a wound is at risk of it becoming infected. However, there are certain factors that can increase this risk, which can vary depending on the individual, the wound, the pathogen and the environment (International Wound Infection Institute 2022). Box 3 provides examples of factors that increase the risk of wound infection.

An increased risk of wound infection may be associated with certain surgical procedures, and in England it is mandated for hospitals undertaking orthopaedic surgical procedures to report annually on surgical site infection for hip, knee, reduction of long bone fractures and fractured neck of femur procedures (Public Health England (PHE) 2022). The reporting of surgical site...
infection associated with various other surgeries is also encouraged (PHE 2022). This annual reporting contributes to the understanding of risk of wound infection associated with surgery. NHS Wales (2022) and Public Health Scotland (2022) also collect surgical site infection surveillance data. In England, the National Wound Care Strategy Programme (2021) has produced recommendations for the management of surgical wounds from pre-surgery assessment through to care in the community post-discharge.

**TIME OUT 1**
Consider the recommendations for the preoperative phase detailed in the National Institute for Health and Care Excellence (NICE) (2019) guideline on Surgical Site Infections: Prevention and Treatment. How does your local area of practice comply with these recommendations?

### Preventing wound infection
In relation to preventing surgical site infections, NICE (2013, 2019) has produced guidance that directs healthcare teams in preoperative, perioperative and post-operative care to reduce the risk of infection. Surgical site infection surveillance (PHE 2022) also contributes to understanding how this risk can be reduced.

In some surgical departments and specialties, single-use incisional negative pressure wound therapy devices are increasingly being used to reduce the risk of infection and dehiscence (Shiroky et al 2020, Norman et al 2022). Negative pressure wound therapy uses suction applied to the wound bed via a medium of gauze or foam to facilitate rapid tissue regrowth and the removal of exudate (Sandoz 2015). Single-use incisional devices are small and easy for the patient to wear; they involve the use of a silicone foam adhesive dressing that is laid over the closed wound and attached to a small battery or mechanically powered pump (Sandoz 2015). This can be effective for some high-risk patients (World Union of Wound Healing Societies 2018). A Cochrane review by Norman et al (2022) concluded that those patients treated prophylactically with single-use incisional negative pressure wound therapy following surgery probably experienced fewer surgical site infections than those treated with standard dressings, but there was probably little or no reduction in wound dehiscence.

**TIME OUT 2**
Consider the recommendations for the preoperative phase detailed in the National Institute for Health and Care Excellence (NICE) (2019) guideline on Surgical Site Infections: Prevention and Treatment. How does your local area of practice comply with these recommendations?

The prevention of infection in chronic wound care centres on effective hygiene following the principles of asepsis (absence of pathogenic organisms)

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**Key points**

- Wound infection can delay healing and can result in hospitalisation, loss of limb, or loss of life if sepsis develops
- A holistic wound assessment, effective wound hygiene, cleansing and management, debridement and maintenance of a healthy individual can all reduce the likelihood of development of a wound infection
- Nurses need to adhere to effective wound management practices and optimal infection prevention and control procedures
- Patients involved in managing their wounds should understand and adhere to effective wound hygiene techniques and be aware of the signs and symptoms of infection

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**Figure 1. Wound infection continuum**

- **Contamination**
  - Microbes are present but not proliferating
  - No host reaction
  - Host defences are able to destroy microbes
  - Wound healing is not delayed

- **Colonisation**
  - Microbes are present and proliferating
  - No host reaction
  - Host defences are able to destroy microbes
  - Wound healing is not delayed

- **Local infection**
  - Microbes are proliferating and stimulating a host reaction
  - Local host reaction at the wound bed may initially present as covert signs and symptoms before these become increasingly overt

- **Spreading infection**
  - Surrounding tissue becomes invaded
  - Signs and symptoms of infection spread beyond the wound edge and may involve deeper tissues, such as fascia or muscle

- **Systemic infection**
  - The host will be unwell
  - Sepsis could develop

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**Vigilance required**
- No antimicrobials indicated

**Intervention required**
- Topical antimicrobial
- Systemic and topical antimicrobials

(Adapted from International Wound Infection Institute 2016. Reproduced with permission)
while performing wound care (Pegram and Bloomfield 2015), appropriate wound assessment, cleansing and management, debridement and maintenance of a healthy individual (International Wound Infection Institute 2016). Aseptic technique entails a non-touch method using sterile materials, such as sterile wound dressing packs and dressings. A thorough and holistic assessment that incorporates the components of a generic wound assessment as shown in Table 1 should take place at the first presentation of the person with the wound or within six hours of their admission to hospital (Coleman et al 2017, Wounds UK 2018). Reassessments should then be scheduled according to the needs of the patient and the wound (Wounds UK 2018). For instance, a debriding, highly exuding or infected wound may need more frequent assessment than a wound that is granulating and responding to treatment.

According to manufacturers’ guidance, most dressings can remain in situ for up to seven days, with earlier reassessment dates being determined by how well the wound is responding to treatment. Some patients may experience pain during dressing changes that is challenging to manage, so dressing changes and assessments may be undertaken less frequently. Complete documentation of any wound assessments, including photographs, can support early identification of infection and/or deterioration of the wound. Addressing the underlying wound aetiology – for example by managing venous leg ulcers (National Wound Care Strategy Programme 2020a) – can improve some of the symptoms, such as high levels of exudate, which microbes can favour (International Wound Infection Institute 2022).

With patients increasingly self-managing or sharing the care of their wounds (Moore et al 2021), it is important to ensure they understand and adhere to effective wound hygiene techniques when undertaking wound care and changing their dressings. Demonstrating and advising on how to wash their hands, remove and dispose of old dressings, apply sterile gloves and how to apply the new dressing form part of the support that nurses can provide. Patients also need to be aware of the signs and symptoms of wound infection, how to recognise these early and who to report this to promptly (National Wound Care Strategy Programme 2020b, PHE 2021). Providing written information to support verbal advice ensures that patients have literature to refer to in the absence of healthcare practitioners.

TIME OUT 3
Consider what you understand about the signs and symptoms of wound infection. Now think about patients who may have reduced or masked signs and symptoms of infection, for example those with conditions that reduce their immune response. How might you determine the presence of a wound infection in these patients?

Identifying wound infection
Box 4 shows the signs and symptoms of local wound infection. Recognising these signs and symptoms is essential to commencing appropriate treatment rapidly. Wound infection can lead to surrounding and spreading cellulitis (an acute infection of the skin), necrotising fasciitis (a serious, rapidly spreading infection of the soft tissues under the skin), loss of limb, sepsis and possibly death (International Wound Infection Institute 2022).

The identification of a wound infection is primarily based on clinical observation of the patient’s signs and symptoms. Where signs of spreading infection or systemic response are evident, a wound swab for microbiological sampling may be required to ascertain the pathogenic microbe and the most appropriate antibiotic. A wound swab does not identify an infection – it only provides an indication of the level of microbe presence, with the most prevalent being the likely causative pathogen, and the sensitivity of that microbe to antibiotics (PHE 2018).

A negative swab result does not necessarily mean there is no infection present (World Union of Wound Healing Societies 2018). When taking a wound swab, the wound should first be cleansed and debrided (PHE 2018). Malodour is a common sign of infection and different smells can be associated with different pathogens (Ousey et al 2017). An experienced healthcare practitioner may be able to differentiate microbes by smell, but this can be highly subjective and people's ability to use this sense differs. Electronic noses may have a role in wound care in the future, removing subjectivity and enhancing the early detection of wound infection (Ousey et al 2017).

It is recognised that most chronic wounds will have biofilm present (Malone et al 2017, Swanson et al 2017); therefore, biofilm prevention and management strategies are crucial in managing infection in these wounds (Wounds UK 2017). Identification of biofilm is highly challenging, with stalled healing the most cited symptom (Swanson et al 2017). However, friable granulation tissue (Figure 3), failure to respond to systemic or topical antimicrobial treatment, recurrence of delayed
healing following antimicrobial treatment, low-level chronic inflammation and secondary signs of infection are all cited as indicative of the potential presence of biofilm (International Wound Infection Institute 2016, Haesler et al 2019). Identifying biofilm using a wound swab is ineffective and it may be more useful to take a biopsy.

One scientific advancement in terms of dressing design is intuitive or ‘smart’ dressings, which indicate when a wound is developing an infection, perhaps through a change in pH (O’Callaghan et al 2020, Faramarzi and Tamayol 2021). Having a dressing that can indicate the presence of infection – for example via electronic means or colour change – will enhance healthcare practitioners’ ability to commence appropriate treatment early.

When wound infection is suspected, routine clinical observations – that is, temperature, heart rate, respiratory rate, blood pressure, level of consciousness and oxygen saturation – should be taken to establish if there are systemic signs of infection (NICE 2016). The National Early Warning Score 2 (NEWS2) (Royal College of Physicians 2017) is recommended by NICE (2016) and endorsed by NHS England and NHS Improvement (2022) to support early identification of deterioration, which may be associated with sepsis. Healthcare practitioners, including nurses, should advise the patient, family and carers at home to observe for signs of wound infection and sepsis, including feeling unwell, new pain in the wound, increased exudate or leaking from the wound, a high or low temperature, raised heart rate, breathlessness and reduced urine output (NICE 2016). Healthcare practitioners should also ensure the patient and those around them are aware of the signs and symptoms of sepsis, receive appropriate literature and know to call appropriate emergency or other healthcare services for assistance when required.

**Managing wound infection and biofilm**

Adhering to and maintaining the actions to reduce risk of infection are important when managing infection. Optimising the individual’s ability to combat infection, reducing the microbial load at the wound bed and managing the environment to prevent cross-contamination are all recommended practices for managing an infected wound (International Wound Infection Institute 2016). Underpinning these practices is a holistic assessment that considers the patient, wound and environment-related factors that might be adversely affecting wound healing and infection (Coleman et al 2017, Wounds UK 2017).

When selecting appropriate products for wound management, it is important to consider other wound characteristics such as exudate levels, presence of sloughy tissue, wound pain and the site of the wound. Awareness of allergies or contraindications to using a particular antimicrobial will also guide selection. Healthcare practitioners should consult the local wound dressings

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**Box 3. Examples of factors that increase the risk of wound infection**

- Anatomical site of the wound, for instance if the bowel is in close proximity
- Diabetes mellitus
- Devitalised tissue in the wound bed
- Emergency surgery
- Environment, such as unhygienic home conditions or a cramped caregiving space
- Immunosuppression
- National Healthcare Safety Network risk index score of 2 or 3
- Obesity
- Reduced tissue perfusion
- Site of surgery – the highest risk of wound infection is with bile duct, liver or pancreatic surgery followed by large bowel surgery
- Suboptimal hand hygiene
- Suboptimal wound care and management
- Wound chronicity


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**Table 1. Components of a generic wound assessment**

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Holistic patient assessment – general health</strong></td>
<td>- Factors affecting healing, for example smoking, comorbidities affecting oxygenated blood levels such as vascular disease, anaemia or suboptimal nutritional status&lt;br&gt; - Medicines affecting healing such as corticosteroids&lt;br&gt; - Psychological issues such as stress and anxiety&lt;br&gt; - Quality of life and the effect of the wound on this&lt;br&gt; - Allergies and sensitivities</td>
</tr>
<tr>
<td><strong>Wound assessment</strong></td>
<td>- Type, number and location of the wound&lt;br&gt; - Wound size – length, width and depth&lt;br&gt; - Wound duration&lt;br&gt; - Wound bed, tissue type and amount. For example, the presence of necrotic, sloughy, granulation and epithelial tissue in the wound&lt;br&gt; - Amount, consistency, type and colour of exudate&lt;br&gt; - Presence of malodour&lt;br&gt; - Presence of wound pain – frequency and severity&lt;br&gt; - Undermining or tunnelling – clockface times can be used to identify the direction&lt;br&gt; - Colour and condition of the surrounding skin&lt;br&gt; - Signs of local and systemic infection&lt;br&gt; - Whether the wound has healed</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>- Undertake appropriate investigations, such as ankle brachial pressure index for leg ulcers&lt;br&gt; - Make appropriate referrals, for example to tissue viability, dermatology, vascular, surgical or plastics departments</td>
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(Coleman et al 2017)
formulate and study the information leaflet within the box of dressings to see if is suitable for the patient.

Box 5 details some of the management options for wound infection.

Biofilm management centres on disruption of the fixation of the biofilm to the wound bed. The cornerstone of biofilm management is debridement, which is the removal of devitalised tissue and biofilm. There are several methods of debridement that can disrupt biofilm, including surgical, sharp and larval debridement, with no evidence supporting one method over another (Wounds UK 2017). When deciding which method to use, several factors should be considered, such as suitability for the patient, the skill of the healthcare practitioner, available equipment and resources, as well as cost. It is unlikely that surgical debridement, which requires theatre time, a surgeon and anaesthetic, will be selected purely to remove biofilm. However, sharp or larval debridement might be alternative, less costly options. Debridement is only one element of the strategy to eradicate biofilm; it needs to be followed by measures to prevent its reformation. To do this, an antimicrobial dressing should be selected that has proved effective against biofilm, to prevent it from reattaching and reforming (Wounds UK 2017).

When selecting which antimicrobial to use, it is important to consider how often the dressing needs to be changed; this will be based on levels of exudate, the antimicrobial and the frequency of debridement required. In accordance with NICE (2015) guidelines on antimicrobial stewardship, which recommend prescribing the shortest effective course, healthcare practitioners should ensure that the effectiveness of the antimicrobial is monitored, reviewed at two weeks, and continued or discontinued depending on the presence or absence of signs of infection (Wounds UK 2017).

If at the two-week review the decision is made to continue with the antimicrobial, then this should be reviewed at least every two weeks. If the antimicrobial is not demonstrating effectiveness, then another antimicrobial should be considered. If the wound is deteriorating despite the use of an antimicrobial, other causes of this deterioration – such as pressure or suboptimal management of venous leg ulcers – should be considered and addressed. Changing the antimicrobial may also be appropriate (Wounds UK 2017).

Conclusion

Wound infection can delay healing, lead to hospitalisation and result in loss of limb or life if sepsis develops. Early intervention in chronic wounds such as venous leg ulcers, prevention of wounds such as pressure ulcers, and prevention of surgical site infection are primary strategies to reduce wound infection rates.

When wounds are present, a full holistic wound assessment, effective wound hygiene following the principles of asepsis, cleansing and management, debridement and maintenance of a healthy individual can all contribute to reducing the risk of infection. All nurses and other healthcare practitioners who are responsible for managing a wound need to adhere to effective wound management practices and optimise infection prevention and control. Since patients have an increasing role in wound care, it is important that they are also well informed about how to prevent infection and how to identify the signs and symptoms of an infected wound.

TIME OUT 5
Identify how preventing and managing wound infections applies to your practice and the requirements of your regulatory body

TIME OUT 6
Now that you have completed the article, reflect on your practice in this area and consider writing a reflective account: rcni.com/reflective-account
Wound infection
TEST YOUR KNOWLEDGE BY COMPLETING THIS MULTIPLE-CHOICE QUIZ

1. Which statement is false?
   a) Infection is more likely in chronic wounds than acute wounds
   b) Infection can delay healing in chronic wounds
   c) Infection is more likely in acute wounds than chronic wounds
   d) All wound types carry a risk of developing an infection

2. During the local infection phase of the wound infection continuum:
   a) Microbes are present but not proliferating
   b) Surrounding tissue becomes invaded
   c) Microbes are proliferating and stimulating a host reaction
   d) Signs and symptoms of infection spread beyond the wound edge and may involve deeper tissues

3. The presence of biofilm in a wound:
   a) Is easy to recognise visually
   b) Can contribute to wound chronicity
   c) Increases the effectiveness of usual infection management strategies
   d) Rarely occurs in the presence of slough

4. Which of the following is not a factor that can increase the risk of wound infection?
   a) Suboptimal hand hygiene
   b) Devitalised tissue in the wound bed
   c) Obesity
   d) Optimal tissue perfusion

5. The prevention of infection in chronic wound care centres on:
   a) Effective hygiene following the principles of asepsis while performing wound care
   b) Appropriate wound assessment, cleansing and management
   c) Maintenance of a healthy individual
   d) All of the above

6. Which statement is true?
   a) A wound swab for microbiological sampling should not be taken where there are signs of spreading infection or systemic response
   b) A wound swab should only be taken when there is malodour from the wound
   c) A wound swab does not identify an infection – it only provides an indication of the level of microbe presence
   d) A negative wound swab result always means that infection is not present

7. One of the covert signs and symptoms of local wound infection is:
   a) Epithelial bridging
   b) Erythema
   c) Local warmth
   d) Swelling

8. Which of these is not indicative of the potential presence of biofilm?
   a) Friable granulation tissue
   b) Failure to respond to systemic or topical antimicrobial treatment
   c) Rapid healing following antimicrobial treatment
   d) Low-level chronic inflammation

9. What is considered the cornerstone of biofilm management?
   a) Debridement
   b) Anti-inflammatories
   c) Surgical intervention
   d) Polypharmacy

10. When selecting appropriate products for wound management, it is important to consider:
    a) Exudate levels
    b) Presence of sloughy tissue
    c) Site of the wound
    d) All of the above

How to complete this quiz
This multiple-choice quiz will help you to test your knowledge. It comprises ten questions that are broadly linked to the CPD article. There is one correct answer to each question.

- You can test your subject knowledge by attempting the questions before reading the article, and then go back over them to see if you would answer any differently.
- You might like to read the article before trying the questions.

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This multiple-choice quiz was compiled by Alex Bainbridge

The answers to this multiple-choice quiz are:
a) c b c d a
b) a c d b

This activity has taken me __ minutes/hours to complete. Now that I have read this article and completed this assessment, I think my knowledge is:

Excellent □ Good □ Satisfactory □ Unsatisfactory □ Poor □

As a result of this I intend to: ________________________________

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