DIALKYLCARBAMOYL CHLORIDE-COATED WOUND DRESSINGS: AN EVIDENCE REVIEW AND POSITION DOCUMENT

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Foreword

The prevention, treatment and management of wound infection consistent with antimicrobial stewardship is a global concern and yet one of the greatest obstacles for clinicians, considering wound infection severely impacts patient outcomes, clinical practices and financial costs. The lack of clinical evidence with high certainty, of the plethora of topical antimicrobial dressings available for the clinicians appropriate selection adds to the challenge of wound infection management, when evidenced based practice is the practitioner's foundation in healthcare.

Antimicrobial resistance (AMR) which occurs when bacteria, viruses, fungi and parasites no longer respond to antimicrobial medicines is a growing healthcare concern. The World Health Organisation (WHO) has identified AMR as being one of the top global public health and development threats. Wound infections caused by antimicrobial resistant pathogens pose a considerable challenge to treatment, increasing complexity, time requirements, and costs while also limiting available therapeutic options.

The search for new antimicrobial agents has expanded beyond traditional antibiotics, whose development has been scarce over the past two decades, to include innovative technologies such as photodynamic therapy, phage therapy, and advanced wound dressings that use physical antimicrobial mechanisms. Among these, DACC (Dialkylcarbamoyl Chloride) -coated wound dressings have demonstrated significant anti-infective efficacy in both laboratory and clinical studies.

A group of experts from the United Kingdom, Europe and South Africa identified the need for an evidenced review to provide internationally recognised guidance for the use of DACC dressings, based on the available evidence.

A narrative review of the literature is presented in each chapter of this position document presenting and critically examining the published in vitro and clinical evidence surrounding the antimicrobial capabilities of DACC-coated wound dressings and how DACC can be aligned with AMS in the prevention, treatment and management of infection to enable wound healing, in acute, chronic and hard to heal wounds.

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Evaluating the in vitro evidence supporting the clinical action of DACC-coated wound dressings in the management of infection and enabling healing

Introduction: When the skin is injured, its barrier is compromised, allowing microorganisms to enter and become established in the wound bed (Felgueiras, 2021). In acute wounds, microbial presence is minimal, and healing progresses without major issues (Felgueiras, 2021). However, in chronic wounds, disrupted healing alters interactions between microorganisms and immune cells, leading to persistent infections and inflammation (Tomic-Canic et al, 2020; Felgueiras, 2021). If microbes attach and proliferate, they may form a biofilm, which protects them from immune responses and antimicrobial treatments, contributing to making chronic wounds harder to heal (Percival et al, 2015; Høiby, 2017; Krzyżek, 2024).
Aim: To identify animal- and laboratory-based evidence exploring the effectiveness of DACC-coated dressings for the management of bioburden via the binding and removal of microorganisms, and any effect on cells important for wound progression.
Methods: A narrative review of the literature was conducted using free-to-access online resources, including PubMed/MEDLINE and Google Scholar. These databases were searched using the keywords 'DACC', 'Dialkylcarbamoyl Chloride', 'Sorbact' and 'vitro'.
Original laboratory-based studies featuring DACC-coated dressings assessing antimicrobial activity or effects on cells important for wound healing were included. Exclusion criteria included articles that were not original study articles (e.g. reviews), articles not published in English and articles appraised as not being relevant to the inclusion criteria.
Results: A total of 36 articles were identified. Following exclusion of papers 19 articles were included for review (Wadström et al,1985; Bowler et al, 1999; Ljungh et al, 2006; Hastings, 2009; Rosana et al, 2009; Falk and Ivarsson, 2012; Brackman et al, 2013; Braunwarth and Brill, 2014; Braunwarth et al, 2014; Geroult et al, 2014; Ronner et al, 2014; Larkö et al, 2015; Cooper and Jenkins, 2016; Husmark et al, 2022; Morgner et al, 2022; Ortega-Peña et al, 2022; Susilo et al, 2022; Meredith et al, 2023; Malone et al, 2024) **[see Supplementary Table 1].**

Scan the QR code to access supplementary table 1

Evidence to support DACC-coated dressing for broad-spectrum non-medicated antimicrobial activity

Planktonic bacteria

Bacteria naturally exist in two primary states: free-living (planktonic) in fluids or attached as a biofilm (Percival et al, 2015). The presence of biofilms in chronic wounds was first reported in 2008 (Bjarnsholt et al, 2008; James et al, 2008), with subsequent studies estimating their prevalence at nearly 80% (Malone et al, 2017). This suggests that biofilms are the predominant bacterial form in such wounds. However, evidence shows that chronic wounds also contain scattered single bacterial cells and small clusters (Lichtenberg et al, 2024).

Fourteen studies (Wadström et al, 1985; Bowler et al, 1999; Ljungh et al, 2006; Hastings, 2009; Rosana et al, 2009; Braunwarth and Brill, 2014; Braunwarth et al, 2014; Geroult et al, 2014; Ronner et al, 2014; Husmark et al, 2022; Ortega-Peña et al, 2022; Susilo et al, 2022; Meredith et al, 2023; Malone et al, 2024) evaluated the non-medicated

antimicrobial activity of DACC-coated dressings against planktonic bacteria. An early "proof of principle" study using a porcine burn wound model demonstrated that a cellulose dressing with hydrophobic properties was more effective than an antimicrobial dressing in the management of experimentally infected burn wounds inoculated with *S. aureus*, improving wound healing and eliminating infection by day five (Wadström et al, 1985). Laboratory studies further confirmed the ability of DACC-coated dressings to bind and retain microorganisms like *S. aureus* and *P. aeruginosa* (Bowler et al, 1999).

Ljungh et al (2006) investigated the mechanism of DACC-coated dressings, showing that they rapidly bound bacteria such as *S. aureus*, *P. aeruginosa*, *E. faecalis, F. nucleatum and B. fragilis.* The study found that increasing bacterial concentrations did not saturate the dressing's binding capacity for several bacterial species. Coating fibres with dialkylcarbamoyl chloride (DACC), a fatty acid derivative, conveys a hydrophobic surface (Ljungh et al, 2006). Wound bacteria can possess a high cell surface hydrophobicity (CSH) (Ljungh et al, 2006), which is an important mechanism of adhesion for microorganisms (Doyle, 2000). When the hydrophobic, DACC-coated surface comes into contact with the hydrophobic structures of bacteria, binding between them occurs through hydrophobic interaction and expulsion of water molecules (Ljungh et al, 2006). Then, bacteria bound to DACC-coated dressings enable removal of microorganisms, reducing bacterial presence in wounds without relying on antimicrobial agents.

Husmark et al (2022) further confirmed DACC-coated dressings' antibacterial effects using an industrial standard challenge test. Their results demonstrated irreversible bacterial binding, preventing microorganism release even after extensive washing with a surfactant. Additionally, repeated inoculation tests validated the dressing's long-term antibacterial effectiveness. Multiple in vitro studies have consistently shown that DACC-coated dressings exert antimicrobial effects by binding and removing bacteria, including *S. aureus*, *P. aeruginosa* and other clinically relevant microbes **[see Supplementary Table 1]**.

Studies confirm that while DACC-coated dressings bind bacteria, they do not kill them. Husmark et al (2022) found that bound bacteria remained viable but inhibit bacterial growth. Similarly, Susilo et al (2022) observed no zones of inhibition in antimicrobial assays, suggesting the dressing does not actively kill *P. aeruginosa*. Ortega-Peña et al (2022) found no increase in pro-inflammatory markers when macrophages and fibroblasts were exposed to supernatant culture media from DACC-bound *S. aureus*, indicating bacterial integrity was maintained.

Malone et al (2024) investigated bacterial attachment to and growth on DACC-coated dressings, demonstrating that increasing *P. aeruginosa* concentrations led to higher bacterial adhesion over time, but that this increased adhesion was not seen when the bacterial growth was inhibited. They found a modest but significant reduction in microorganism levels remaining in suspensions after incubation with DACC. The authors suggested that proliferation of attached bacteria to DACC-coated dressing occurs. Other studies contradict this, reporting inhibited bacterial growth upon binding to DACC-coated dressings (Husmark et al, 2022).

A critical aspect of DACC-coated dressings is their ability to remove, rather than kill, bacteria. This is significant since bacterial death can release endotoxins that contribute to inflammation and impede wound healing (Rippon et al, 2022). Ortega-Peña et al (2022) and Susilo et al (2022) suggest no microbial killing occurs and Susilo et al (2022) has shown that DACC-coated dressings significantly reduce purified endotoxin levels by up to 99.95%, as well as *P. aeruginosa*-shed endotoxin by 93-99%.

Evaluating the in vitro evidence supporting the clinical action of DACC-coated wound dressings in the management of infection and enabling healing

In vitro Evidence Keypoints

- Antimicrobial effect on planktonic microorganisms
- Inhibits formation of biofilm and removes biofilm
- Effective on antimicrobial-resistant microorganisms including WHO "priority pathogens"

Biofilms

Biofilms are reported to represent the dominant bacterial state in wounds (Lichtenberg et al, 2024). Percival et al (2015) identified pathogenic biofilms as major contributors to delayed or chronic wound healing. Our review identified four studies assessing the effectiveness of DACC-coated dressings on biofilm (Brackman et al, 2013; Larkö et al, 2015; Cooper and Jenkins, 2016; Meredith et al, 2023). Brackman et al (2013), using an in vitro chronic wound infection model, found that several wound dressings, including DACC-coated dressing, inhibited *S. aureus* biofilm formation. Larkö et al (2015) compared three antimicrobial dressings that act via mechanisms other than active antimicrobial agents. Assessments of bacterial load in the dressings after incubation indicated that all tested dressings, including DACC-coated dressings, effectively removed *P. aeruginosa* biofilm. Similarly, Meredith et al (2023) demonstrated that DACC-coated dressings removed up to 39% of *P. aeruginosa* biofilm after 6 hours in a gauze-biofilm model. Cooper and Jenkins (2016) investigated biofilm attachment to DACC-coated dressings by placing samples in direct contact with mature biofilms of *P. aeruginosa* or MRSA. Scanning electron microscopy revealed biofilm binding to the DACC-coated dressing.

Antimicrobial-resistant microorganisms

Six in vitro studies assessed the microorganism-binding capacity of DACC-coated dressings against antimicrobial-resistant microorganisms (Rosana et al, 2009; Braunwarth and Brill, 2014; Ronner et al, 2014; Cooper and Jenkins, 2016; Husmark et al, 2022; Meredith et al, 2023). Ronner et al (2014) evaluated the binding capacity of multiple MRSA and methicillin-sensitive strains to DACC-coated dressings, finding that all MRSA strains adhered equally well to DACC-coated dressings, regardless of antibiotic resistance. Comparisons with uncoated controls showed significantly lower MRSA binding to uncoated dressings ($p<0.0001$). Several other studies confirm MRSA binding to DACC-coated dressings (Rosana et al, 2009; Braunwarth and Brill, 2014; Cooper and Jenkins, 2016; Husmark et al, 2022), as well as other resistant microorganisms including vancomycin-resistant *E. faecium*, extended-spectrum beta-lactamase (ESBL) *P. aeruginosa* and ESBL *E. cloacae* (Husmark et al, 2022; Meredith et al, 2023).

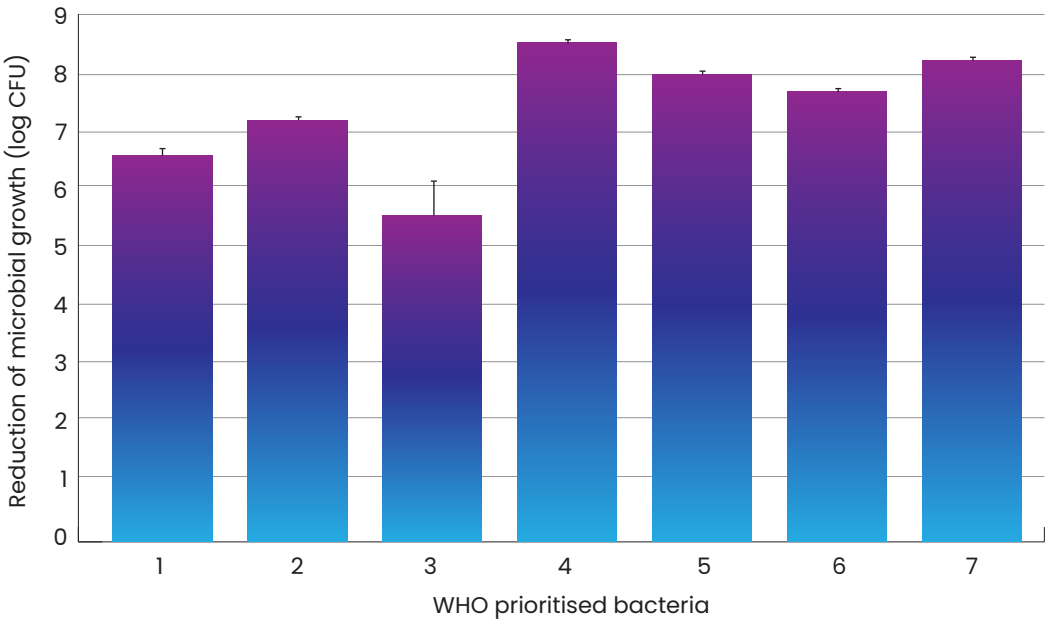
WHO pathogens

In 2017, the WHO published the Bacterial Priority Pathogens List (BPPL) to address the growing threat of AMR and guide research and development of new antimicrobials (WHO, 2017) and was updated in 2024 (WHO, 2024). Many BPPL-listed microorganisms cause wound infections and a review estimated that approximately 70% of bacteria responsible for wound infections are resistant to at least one antibiotic (Liu et al, 2022). This review identified six studies examining the effects of DACC-coated dressings on bacterial strains (planktonic or biofilm) from the BPPL 2024 (Rosana et al, 2009; Braunwarth and Brill, 2014; Ronner et al, 2014; Cooper and Jenkins, 2016; Husmark et al, 2022; Meredith et al, 2023). Using a standardised challenge test (JIS L 1902), Husmark et al (2022) demonstrated a strong reduction of all tested resistant WHO-prioritised bacteria **[Figure 1]**. The DACC-coated dressing completely inhibited the growth of *S. aureus*, *P. aeruginosa*, *E. cloacae* and *A. baumannii*. The authors suggested these results help explain the reduced bioburden and improved wound healing observed in clinical practice with DACC-coated dressings. Additionally, multiple studies confirm the binding and removal of both planktonic (Rosana et al, 2009; Braunwarth and Brill, 2014; Ronner et al, 2014) and biofilm-forming MRSA (Cooper and Jenkins, 2016), reinforcing the benefits of DACC-coated dressings in managing BPPL-listed microorganisms.

DACC interaction with fungi

While bacteria play a role in impairing healing of chronic non-healing wounds, fungi also play a role (Kalan and Grice, 2018; Ge and Wang, 2023). Few in vitro studies have examined fungal binding to DACC-coated dressings. This review identified only

Figure 1: Testing of the antibacterial activity of the dialkylcarbamoyl chloride-coated dressing according to JIS L 1902 showed a strong antibacterial activity against the WHO-prioritised bacteria strains (adapted from Husmark et al, 2022)



1 - *S. aureus* (sensitive)
2 - *S. aureus* (MRSA)
3 - *E. faecium* (VRE)
4 - *P. aeruginosa* (Sensitive)
5 - *P. aeruginosa* (ESBL)
6 - *E. cloacae* (ESBL)
7 - *A. baumannii*

two relevant studies, showing adherence of Candida albicans to DACC-coated dressings (Ljungh et al, 2006; Ronner et al, 2014).

DACC interactions with wound healing cells

The clinical suitability of antimicrobial dressings, such as DACC-coated dressings, depends on more than just their interaction with microorganisms. Factors like dressing adherence to the wound surface and their effects on key wound-healing cells (e.g. inflammatory cells, fibroblasts, epithelial cells) are also important considerations (Wiegand et al, 2019). This review identified three studies examining the effects of DACC-coated dressings on wound-healing cells (Falk and Ivarsson, 2012; Morgner et al, 2022; Ortega-Peña et al, 2022). Falk and Ivarsson (2012) observed that fibroblasts did not adhere easily to the dressing material, and in an in vitro scratch wound healing model, the presence of the dressing enhanced the healing response. The authors concluded that DACC-coated dressings promote wound healing by stimulating fibroblast proliferation and migration. Morgner et al (2022) confirm that DACC-coated dressings did not delay healing or scratch wound closure. Ortega-Peña et al (2022) explored the indirect effects of DACC-coated dressings on fibroblast and macrophage activity. Co-cultures of these cells were exposed to filtered supernatants from *S. aureus* cultures treated with DACC-coated dressings. The study showed no excessive stimulation of fibroblast/macrophage TNF-alpha or TGF-beta1 ($p<0.001$), suggesting that bacterial integrity was maintained during exposure of bacteria with DACC, and that the dressing did not provoke an overactive inflammatory response.

Limitations and future directions

Within the set of studies identified, there were a range of microorganisms used, each of which display variations in attachment

In vitro Evidence Keypoints

- Cells important for wound healing do not readily adhere to DACC-coated dressings
- DACC-coated dressings do not impair wound healing

properties than others. In addition, the use of different experimental conditions (e.g. inoculum concentrations) between studies can significantly impact individual study results. This makes in vitro studies difficult to compare, and different methodologies may result in different (and contrary) outcomes of studies. The importance of controlled studies, run with replicates and comparable strains, for comparable inoculation durations is critical for directly comparing the efficacy of test materials. These considerations can help explain some of the general variation in outcomes in the DACC studies.

Conclusions

The in vitro evidence provides support for the clinical action of DACC-coated dressings, promoting the binding and removal of a number of microorganisms including several antibiotic-resistant and WHO Priority List microbes. Wound dressings that act via physical binding (via the hydrophobic mechanism)—which does not involve the use of any antimicrobial agents—use the properties of the dressing material to reduce bioburden by physically removing bacteria, thereby promoting wound healing progression. These wound dressings show clinically proven efficacy in reducing wound bioburden (including antibiotic resistant microorganisms), preventing wound infection, and decreasing the use of antibiotics.

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Evaluating the clinical impact of using a DACC-coated wound dressing in the treatment of acute and chronic wounds in enabling healing, preventing and treating infection: a scoping review

Introduction: There is a significant level of evidence supporting the use of DACC-coated wound dressings in the treatment of acute and chronic wounds for both prevention and treatment of wound infection. Numerous in vitro studies have demonstrated the bacteria-binding properties of DACC-coated wound dressings, showing their ability to bind and retain various types of bacteria to the dressing, leading to an antimicrobial effect (Ljungh et al, 2006; Ronner et al, 2014; Husmark et al, 2022; Morgner et al, 2022; Ortega-Peña et al, 2022; Susilo et al, 2022). Additionally, clinical studies have highlighted their effectiveness in managing bacterial burden and reducing infections in both acute and chronic wounds (Meberg and Schøyen, 2012; Gentili et al, 2012; Stanirowski et al, 2019; Totty et al, 2019; Romain et al, 2020; Ciprandi et al, 2022), and it has been suggested that, since DACC-coated dressings physically remove bacteria rather than actively killing them, the use of DACC-coated dressings minimises the release of toxic bacterial byproducts such as endotoxins that are released into wounds during bacterial killing, and which may negatively impact healing (Rippon et al, 2022; Susilo et al, 2022). Furthermore, DACC-coated dressings have been associated with improved wound healing outcomes (Mussi and Salvioli, 2004; Haycocks and Chadwick, 2011; Brambilla et al, 2013; Romain et al, 2020; Sebayang and Burhan, 2024), reduced treatment costs (Hardy, 2010; Stanirowski et al, 2016a; Gueltzow et al, 2018; Kusu-Orkar et al, 2019; Stanirowski et al, 2019; Magro, 2023), and decreased wound- and dressing change-related pain (Hampton, 2007; Kammerlander et al, 2008; Bullough et al, 2012; Sibbald et al, 2012; Mosti et al, 2015), thereby enhancing patients' quality of life.
Methods: A narrative review of the literature was conducted to explore the role of dialkylcarbamoyl chloride (DACC) wound dressings in the prevention and management of wound infection. Free-to-access online resources, including PubMed/MEDLINE and Google Scholar. These databases were searched using the keywords 'DACC', 'Dialkylcarbamoyl Chloride', 'dialkyl-carbamoyl-chloride', and 'sorbact'. Clinical-based studies (including reviews) featuring DACC-coated dressings were included. Exclusion criteria included articles not in English and articles deemed not relevant to the inclusion criteria. Full texts were reviewed in all cases to determine inclusion in the review.
Results: A total of 1,438 articles were identified. Following exclusion of papers 84 articles were included for review. Details of included articles are summarised in **Supplementary Tables 2 and 3**. Of the 84 articles, eight (9.5%) were systematic reviews and five (6.0%) were other reviews (e.g. narrative reviews), 11 (13.1%) were RCTs, eight (9.5%) were cohort studies, six (7.1%) were case reports, and 42 (50.0%) were case series. An additional four (4.8%) articles were opinion (e.g. commentary, survey) articles. Over half (34/67, 50.7%) of the clinical evidence articles were published since (and including) 2018 **[Figure 2]**. The most common wound type managed with DACC-coated dressing (as measured by number of studies in which wound types are mentioned) was diabetic foot ulcer (n=16, 34.8%), followed by burn (n=13, 28.3%), venous leg ulcer (n=12, 26.1%), pressure ulcer (n=10, 21.7%), post-caesarean surgical wound (n=6, 13.0%), arterial ulcer (n=5, 10.9%), trauma (n=5, 10.9%), and donor site wound (n=2, 4.3%) **[Figure 3]**.

Scan the QR code to access supplementary table 2

Scan the QR code to access supplementary table 3

Prevention and treatment of infection

To determine the effect of DACC-coated dressings for preventing/treatment of infection and/or enabling healing thirteen review articles were identified; 8 records were systematic reviews or meta-analyses (Totty et al, 2017; Jiang et al, 2020; Wijetunge et al, 2021; Evidence Based Procurement Board, 2022; Herrod et al, 2022; Younis et al, 2023; Schwarzer et al, 2024; Rippon et al, 2025a), 4 were narrative reviews (Chadwick and Ousey, 2019; Rippon et al, 2021; Rippon et al, 2023; Jeyaraman et al, 2025), and 1 was a review (Cutting and McGuire, 2015).

A meta-analysis of 5 clinical studies exploring the use of DACC-coated dressings in the reduction of SSIs reported high quality evidence in support of DACC-coated dressings as being effective in reducing SSIs after surgery (Rippon et al, 2025a). Several systematic reviews of DACC-coated dressings reported benefits of using these dressings in the treatment of infection. Totty et al (2017), in an analysis of seventeen studies found limited but encouraging evidence for the management of chronic wounds by DACC dressings and as an SSI prophylaxis for the prevention and treatment of wound infection. In a systematic review and meta-analysis study of 6 clinical studies examining several wound dressings, Wijetunge et al (2021) identified 2 DACC dressing studies with evidence suggesting that DACC-coated dressings potentially reduced SSIs, and Jiang et al (2020) concluded in their meta-analysis that DACC-coated dressings were one of several dressings that significantly reduced the rate of postoperative SSI. Schwarzer et al, (2024) state systematic reviews indicate that DACC-coated dressings, despite lacking an active antimicrobial agent, perform comparably to treatments containing active antimicrobial components.

Several reviews summarise evidence in support of the use of DACC dressings for the prevention and management of wound infection (Cutting and McGuire, 2015; Chadwick and Ousey, 2019; Rippon et al, 2021; Rippon et al, 2023; Jeyaraman et al, 2025) including biofilm (Rippon et al, 2023; Jeyaraman et al, 2025), with further evidence being presented for DACC-coated dressings being cost effective (Jeyaraman et al, 2025). Several reviews suggest that there is a need for more robust clinical studies to be carried

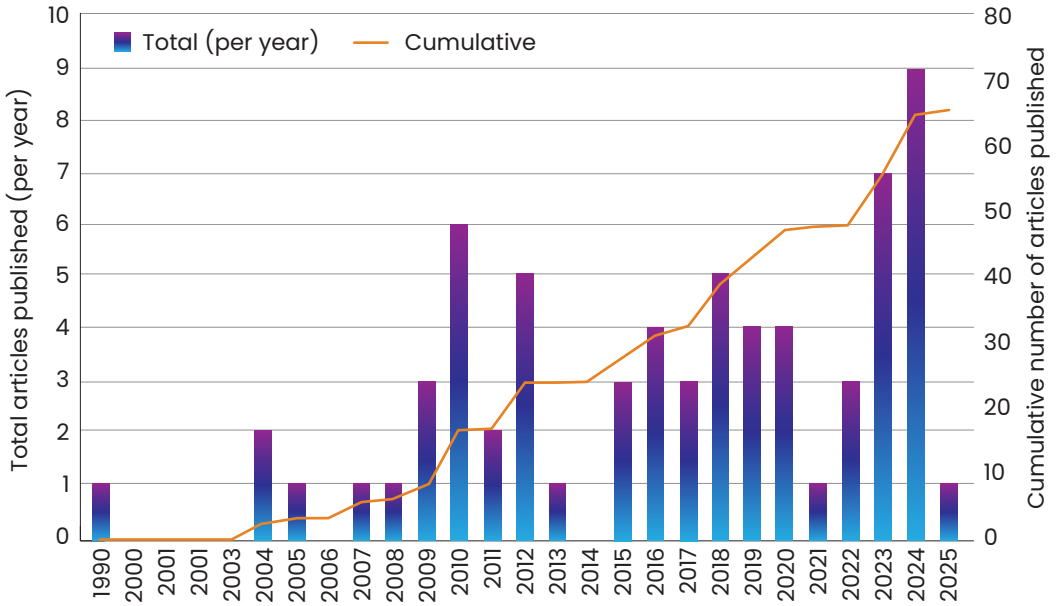
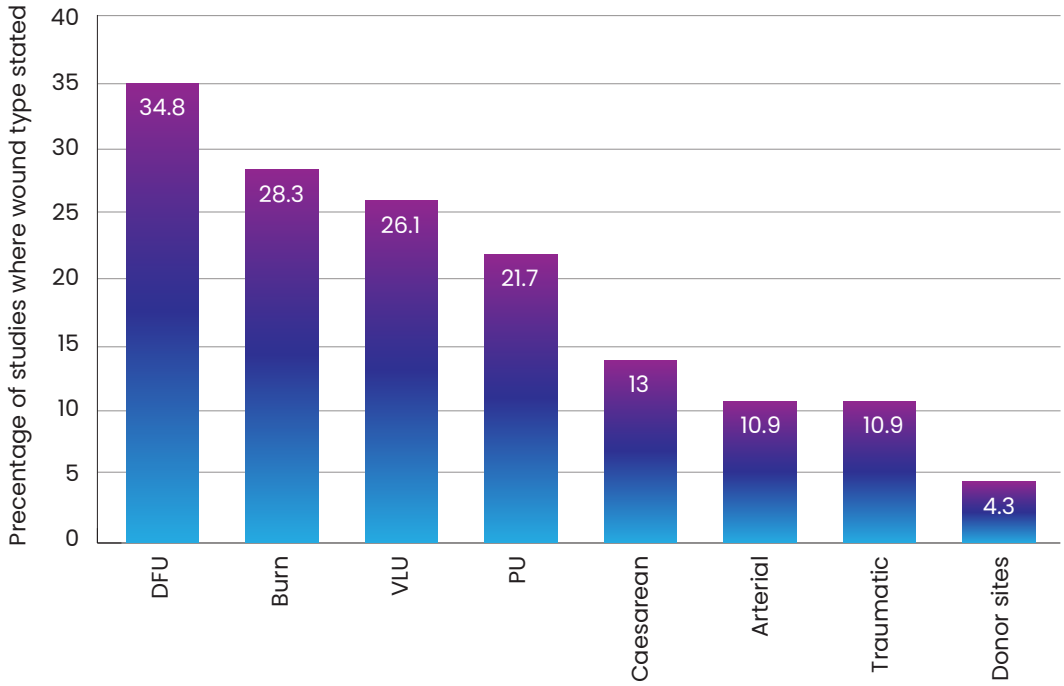


Figure 2: Publication of DACC-coated dressing clinical evidence

Figure 3: Most common wound types managed by DACC-coated dressing



out in support of the clinical benefits of wound dressings, including DACC-coated dressings, for the treatment of wounds of varying aetiologies (Wijetunge et al, 2021; Evidence Based Procurement Board, 2022; Younis et al, 2023; Schwarzer et al, 2024; Jeyaraman et al, 2025).

Clinical evidence

Outcomes

The effect of DACC-coated dressings on management of bioburden

Most wounds are colonised with microorganisms, with levels of microbial colonisation, types of microorganisms, patient's immune response, and the level of devitalised tissue in the wound all affecting the likelihood of infection (Bowler et al, 2001). Many wound microorganisms form a biofilm, a structured polymicrobial community embedded in an extracellular polysaccharide material which adheres to a surface (Flemming and Wingender, 2010). The presence of biofilms results in a wound that is more recalcitrant to treatment (Clinton and Carter, 2015).

Clinical Evidence Keypoints

- Benefits for treatment of wound infection including biofilm
- Prevents wound infection
- Cost-effective

Surgery, because of its invasive nature, can result in the transfer of microbial pathogens into the body via surgical incisions that may result in development of a surgical site infection (SSI) (Bath et al, 2022). These infections are a major cause of morbidity and mortality and are associated with increased rates of complications, hospital stay/readmission, an overall reduction in quality of life and costs of treatment thus are a significant financial burden on healthcare providers (Bath et al, 2022; Pinchera et al, 2022). Several systematic reviews and meta-analyses have shown that DACC-coated dressings reduce the risk of SSI in patients (Totty et al, 2017; Wijetunge et al, 2021; Rippon et al, 2025a).

In this current review, reduced wound bioburden or a reduction in clinical signs of infection was reported by 41 studies. Several studies demonstrated the importance of DACC-coated wound dressings in preventing or treating infection in a variety of wounds in paediatric and neonatal patients.

The clinical evidence reviewed presented data related to a range of wound types:

Acute and surgical wounds: Sixteen studies with approximately 6300 patients (Bullough et al, 2012; Stanirowski et al, 2016a; Stanirowski et al, 2016b: Bua et al, 2017; Corazza et al, 2018; Stanirowski et al, 2019; Totty et al, 2019; Mahyudin et al, 2020; Romain et al, 2020; Taylor et al, 2020; Navarro-Triviño et al, 2022; Magro, 2023; Nicolosi and Parente, 2023; Popplewell et al, 2023; Mulpur et al, 2024), and ten studies of patients with a variety of wound aetiologies (Von Hallern and Lang, 2005; Von Hallern et al, 2004; Kammerlander et al, 2008; Pirie et al, 2009; Stephen-Haynes et al, 2010; Jeffery, 2014; Bateman, 2015; Boyar, 2016; Ciprandi et al, 2022; Dissemond et al, 2023) were included in this review.

Eight studies with 136 patients (Derbyshire, 2010a; Derbyshire, 2010b; Kleintjes et al, 2017; Kleintjes et al, 2018; Kusu-Orkar et al, 2019; Allorto, 2024; Holm et al, 2024; Kleintjes and Prinsloo, 2024), and four multi-aetiology studies (Jeffery, 2014; Bateman, 2015; Dissemond et al, 2023; Iwao et al, 2023) explored prevention and management of infection in burn wounds.

Eleven of the 27 articles that reported reduced bacterial load or the prevention of infections because of wounds treated with DACC-coated dressing featured surgical wounds. As part of a randomised control trial (RCT) to assess efficacy and cost-effectiveness of DACC-coated dressing to prevent surgical site infections, Stanirowski et al (2016a) found SSI rates in the DACC-coated dressing group and a standard surgical dressing (control) group of 1.8% and 5.2%, respectively (p=0.04). Totty et al (2019) studied 144 patients undergoing clean or clean-contaminated vascular surgery in a RCT assessing the use of DACC-coated dressing compared with a control dressing (an occlusive absorbent dressing). The primary clinical outcome was SSI at 30 days and, although this was a feasibility study, they found a 36.9% relative risk reduction in the DACC-coated dressing arm (16.22% versus 25.71%, odds ratio 0.559, P=0.161). The authors recommended a larger, full-scale RCT to confirm these results. In another comparative study, Bua et al (2017) found that DACC-coated dressings were associated with a significant reduction in SSI rates in the early post-operative period after non-implant vascular surgery. The rate of SSI at 5 days was significantly lower in the DACC-coated dressing group compared with the group receiving standard dressings (1% vs. 10%, $p<0.05$). In a series of case studies, the use of DACC-coated dressings was evaluated for the treatment of infected, complex abdominal wounds demonstrating success in controlling or preventing infection (Bullough et al, 2012) with Choi et al (2015) highlighting that DACC-coated wound dressings have been successfully used in preventing infection in skin grafts.

Fourteen of the 41 studies that reported a reduction in infection cited changes in clinical signs of infection. Magro (2023) compared a retrospective audit of women (n=2436) who underwent a caesarean and were treated with an absorbent dressing with a prospective audit of caesarean patients receiving DACC-coated dressing (n=2368). An SSI was recorded if the wound demonstrated heat, redness, pain or swelling. A baseline SSI rate of 6.1% and an SSI readmission of 1.27% reduced to 3.8% and 0.88%, respectively corresponding to a 38% reduction in SSI rate, and a 31% reduction in readmission rates for SSI. This study showed improved clinical outcomes with reduced SSI and readmission rates using DACC-coated dressing.

Neonatal and paediatric wounds

Neonatal and paediatric wounds: Seven studies with 3,878 patients were included in this review (Meberg and Schøyen, 1990; Boyar, 2016; McBride et al, 2018; Kusu-Orkar et al, 2019; Avkan-Oğuz et al, 2020; Lamberti et al, 2023; Nicolosi and Parente, 2023). Paediatric skin is different from the skin of an adult (Telofski et al, 2012; Oranges et al, 2015), although anatomically mature in terms of the presence of the various skin layers when examined histologically (King et al, 2013). However, paediatric skin is a more delicate

and vulnerable structure. For example, the skin of the neonate and infant is thin (Vitral et al, 2018; Stamatas et al, 2010) and there is reduced cohesion between the epidermis and dermis (Evans and Rutter, 1986; Lund et al, 1999). It is a more delicate and vulnerable structure and as such extra care must be taken when applying wound dressings so that they do not cause damage and further exacerbate any clinical conditions (Ciprandi et al, 2022).

Ciprandi et al (2022), assessing their 15-year experience of using DACC-coated dressing in paediatric wound care, suggest that DACC-coated dressings are of benefit for reducing, preventing and treating infection. In a prospective, randomised study (n=2,441), Meberg and Schøyen (1990) assessed DACC-coated dressing for umbilical disinfection in newborn infants and found that a DACC-coated dressing was as effective as routinely used chlorhexidine-ethanol in preventing SSIs in neonates. Lamberti et al (2023) prospective study examining DACC-coated dressing for central venous catheter exit site wounds (n=88) concluded no cases of systematic or local infections. Boyar (2016), in a 3-patient case series study, concluded that DACC-coated dressing provided a bacteriostatic activity without creating cytotoxicity or an inflammatory response in pressure-induced wounds and a dehisced surgical sternal wound in neonates and young children.

Chronic wounds

Chronic wounds: Two studies with 78 patients with venous leg ulcers (Gentili et al, 2012; Brambilla et al, 2013), and eleven studies evaluating leg ulcer management (as a subset of other wound aetiologies) were included in this review (Von Hallern and Lang, 2005; Kammerlander et al, 2008; Powell, 2009; Stephen-Haynes et al, 2010; Bruce, 2012; Sibbald et al, 2012; Bateman, 2015; Mosti et al, 2015; Seckam et al, 2021; Dissemond et al, 2023; Iwao et al, 2023). In the case of pressure ulcers, three studies with 159 patients (Mussi and Salvioli, 2004; Ciliberti et al, 2016; Magdi et al, 2017), and seven multi-aetiology studies (Kammerlander et al, 2008; Stephen-Haynes et al, 2010; Sibbald et al, 2012; Boyar, 2016; Ciprandi et al, 2022; Dissemond et al, 2023; Iwao et al, 2023) were included in this review. Ten studies with 471 patients (Skinner and Hampton, 2010; Haycocks and Chadwick, 2011; Haycocks et al, 2011; Nielsen and Andriessen, 2012; Armi et al, 2023; Malone et al, 2023; Cardilicchia and Todaro, 2024; Malone et al, 2024; Sebayang and Burhan, 2024; Mañas et al, 2025), and eight multi-aetiology studies (Von Hallern and Lang, 2005; Kammerlander et al, 2008; Sibbald et al, 2012; Jeffery, 2014; Bateman, 2015; Seckam et al, 2021; Dissemond et al, 2023; Iwao et al, 2023) were included in this study that featured patients with diabetic foot ulcers. One modelling analysis study included 297,507 patients with chronic wounds (Gueltzow et al, 2018).

The failure of a wound to heal is the result of a complex series of abnormalities in the patient's underlying aetiology, as well as in the local tissue and wound bed (Falanga et al, 2022). A patient's underlying aetiology can result in the abnormal progression of wound healing leading to a chronic inflammatory response in the wound tissue (Zhao et al, 2016). Infection is a major contributor to wound chronicity (Verdolino et al, 2021) with devitalised tissue tending to form in chronic wound beds because of underlying causes (Thomas et al, 2021) and can be a focus for bacterial colonisation and proliferation becoming a nidus for infection (Mayer et al, 2024). Treatment of infection in chronic wounds is of great importance and generally includes thorough debridement to remove dead, devitalised tissue and the use of antimicrobial therapy (Falcone et al, 2021). The management of chronic wounds, and associated colonisation/infection is a serious challenge for wound care practitioners (Frykberg and Banks, 2015) requiring effective and timely management of bioburden (e.g. wound infection) (Eriksson et al, 2022).

For local wound infection, a topical antimicrobial dressing can be used to

Clinical Evidence Keypoints

- Reduced surgical site infection rate and prevention of infection in surgical wounds.
- Evidence supports use in neonatal and paediatric wounds to manage wound infection
- Evidence supports use in management of infection in hard-to-heal wounds such as chronic wounds (e.g. venous leg ulcers, diabetic foot ulcers, pressure ulcers)
- Evidence supports use in removal of biofilm from hard-to-heal wounds

reduce the level of microbial burden at the wound surface, whereas for a spreading infection additional intervention is recommended (e.g. antibiotics, etc.) (IWII, 2022; NICE, 2024). DACC-coated dressings have been found to positively influence bacterial load of a variety of chronic wounds. In a prospective, observational study of 61 patients with infected DFUs, Mañas et al (2025) treatment of these wounds with DACC-coated dressing resulted in a reduction in microbial load, as assessed by presence of biofilm using surrogate biofilm markers developed by the Global Wound Biofilm Expert Panel (Schultz et al, 2017). Gentili et al (2012) conducted an observational study of 15 patients with venous leg ulcers (VLUs) treated with DACC-coated dressing. They found the dressing resulted in a significant reduction in bacterial bioburden in 10 out of 15 patients, with a 254-fold decrease in total bacterial load ($p=0.024$). Ciliberti et al (2016) measured bacterial loads in 50 patients with pressure ulcers (PUs) treated with DACC-coated dressing in combination with negative pressure wound therapy (NPWT). They found a statistically significant reduction of bacterial bioburden in wounds with moderate or high levels of colonisation ($p=0.01$ and $p<0.00001$, respectively) and suggest the use of DACC-coated dressing may have prevented an increase in levels of colonisation in wounds with no or low bacterial loads.

Malone et al (2023), using scanning electron microscopy, confirmed the presence of DFU-derived biofilm adherent to DACC-coated dressings when these dressings were placed on DFUs in 20 patients every 3 days for up to 14 days. The investigators could not confirm any reduction in the mean total microbial load present within the tissue, although when patients were assessed individually, eight participants experienced a reduction of 0.94 Log10 in mean microbial loads pre- versus post-treatment with DACC-coated dressing (4.64 ± 0.9 and 3.7 ± 0.5, $p=0.02$) (Malone et al, 2023).

A reduction in bacterial bioburden was also noted in an RCT in a group of patients with infected pressure ulcers (Mussi and Salvioli, 2004). Patients treated with DACC-coated dressing showed a significant improvement in signs of infection compared to the control group including a reduction of both oedema and peri-lesional erythema ($p=0.028$), and an improvement in the ulcer's wound bed colour ($p=0.034$). In a single-centre, open, non-randomised case series of 29 patients with DFUs, Haycocks and Chadwick (2011) found that treatment with good wound care and DACC-coated dressing for up to 4 weeks led to reductions in the number and severity of the symptoms and signs of infection. By the end of the study, all wounds exhibiting erythema (19/19), pain (6/6) or malodour (6/6), and most wounds with maceration (7/8) and high exudate (23/24) showed improvement. Kammerlander et al (2008), conducted a prospective study in 116 patients with acute and chronic wounds to assess the efficacy of the DACC dressing Cutimed Sorbact. Wounds were assessed as being infected if they showed signs of infection. Of the 98 infections present at the start of treatment, 81% (79/98) showed successful treatment of wound infection with DACC dressing, and in 19% (19/98) of cases wounds with some signs of infection were present at the end of the treatment period. Bruce (2012), in a prospective case series study in patients with infected VLU and traumatic wounds, found that DACC-coated dressings eliminated signs of infection.

Eight studies with 136 patients (Derbyshire, 2010a; Derbyshire, 2010b; Kleintjes et al, 2017; Kleintjes et al, 2018; Kusu-Orkar et al, 2019; Allorto, 2024; Holm et al, 2024; Kleintjes and Prinsloo, 2024), and four multi-aetiology studies (Jeffery, 2014; Bateman, 2015; Dissemond et al, 2023; Iwao et al, 2023) explored prevention and management of infection in burn wounds.

The effect of DACC-coated dressings on wound healing

Wound healing is a complex process involving the coordination of a series

of events with numerous cell types all working together to repair damaged tissue (Guo and DiPietro, 2010). Several factors affecting wound healing include underlying disease processes (Falanga et al, 2022) and infection (Wynn, 2021). Bacterial colonization and infection may contribute to the delayed healing process and present a major challenge for wound care clinicians (Dwiyana et al, 2019). Studies have demonstrated a significant correlation between a wound's microbial bioburden and its healing trajectory (Loesche et al, 2017), and the persistence of wound infections significantly contributes to delayed healing (Han and Ceilley, 2017).

In this review, the effect of DACC-coated dressings on wound healing was evaluated in 30 studies in wounds of varying aetiologies. For acute wounds, Romain et al (2020), in a comparative randomised study of 246 patients undergoing pilonidal sinus excision where DACC-coated dressing was compared with alginate dressings, showed that there were significantly more patients with completely healed wounds after 75 days in the DACC group (75.7%) than in the alginate group (60.0%) (P=0.023). Mayhudin et al (2020) conducted a prospective observational study on patients (n=25) with acute orthopaedic or trauma wounds treated with either DACC-coated dressing or a standard wound dressing. Using the Bates-Jensen Wound Assessment Tool (BWAT) (Bates-Jensen et al, 2019), the BWAT score was significantly lower in the DACC-coated dressing versus the standard dressing (27.60 ± 2.06 vs. 30.70 ± 2.36, $p<0.05$) indicating significantly better wound progression for the DACC-coated dressing. Lee et al (2018) evaluated the wound healing efficacy of DACC-coated dressing for skin graft donor sites. The records of sixty patients who underwent split-thickness skin grafts were retrospectively evaluated for wound healing times. Wounds treated with DACC-coated dressing had shorter healing times compared with wounds treated with conventional foam dressings in patients with "thick skin wounds" (harvested skin thickness of 10-14/1000 inches) (9.5 vs. 12 days, p=0.049) and "thin skin wounds" (8-10/1000 inches) (10 vs. 18 days, p=0.013). Kusu-Orkar et al (2019) conducted a 10-patient case series study on the use of DACC-coated dressing to treat superficial-partial thickness burn injuries (20% flame, 80% hot water) in children (age range, 11 months to 8 years). Treatment with DACC-coated dressing resulted in 50% of wounds healed within seven days, 70% within 14 days, and 100% within 21 days
There is evidence to support DACC-coated dressings assisting in wound progression in patients with chronic wounds. Sebayang and Burhan (2024) demonstrated in a single-blind, fold-over, randomised controlled study of 162 with diabetic foot ulcers that, at day 90, DFUs treated with DACC-coated dressing reduced in size and that this reduction was significantly better compared to cadexomer iodine 0.9% treatment (p=0.016). In a case-controlled study of 33 patients with PUs, wounds treated with DACC-coated dressings were compared with those treated with standard of care including mobilisation, broad-spectrum systemic antibiotic, topical treatment with povidone-iodine solution, collagenase and medicated plasters (Mussi and Salvioli, 2004). Patients treated with DACC-coated dressing showed significant improvement in their wounds, including a reduction in mean days of treatment (9 ± 2 vs. 11 ± 2.1 days, p=0.041. Haycocks and Chadwick (2011) conducted a case series study in 19 patients with 29 DFUs and treated with DACC-coated dressings for up to 4 weeks. All wounds decreased in wound size during the study period with eight (27.6%) wounds healing completely, and a further 20 wounds (69.0%) showed a reduction of >50% in size. In another case series study (Brambilla et al, 2013), 63 patients with VLUs were treated for 12 weeks with DACC-coated dressing. Approximately 85% of wounds were significantly reduced in size, and 53% of wounds healed completely within 12 weeks.

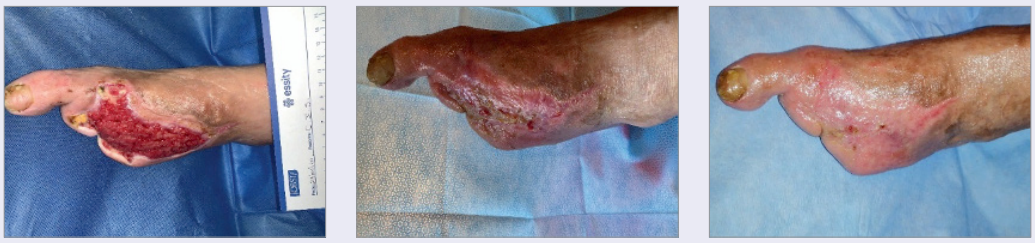
Kammerlander et al (2008) conducted a 116 patient multi-centre case series study to assess the efficacy of DACC-coated dressing in a variety of wounds, including

chronic wounds of different aetiologies (59%). DACC-coated dressing was found to have a positive effect on wound progression with 24 (21%) wounds having healed and eighty-four (72%) wounds showed improvement (e.g. reduced signs of inflammation, increased amount of granulation tissue or epithelialisation). In a 32-patient case series study carried out over six months, DACC dressings were evaluated on a variety of acute and chronic wounds (Stephen-Haynes et al, 2010). The authors reported a positive experience using the DACC dressings. Of the 14 patients who received DACC-coated dressing, four cases were viewed as showing improvements in

Clinical Case 1: 69-year-old male patient with diabetic foot ulcer.

Patient with history of hypertension and long-standing diabetes mellitus. Due to local gangrene, the infection was treated with surgery leaving an extensive ulcer. Patient presented with a dorsal ulcer measuring 9.5 cm in length, 5 cm in width, and 0.5 cm in depth. The case presented with 80% granulation tissue, and 20% slough with tendon exposure, abundant biofilm, moderate serous exudate, slight malodour, and healthy periwound. To achieve wound progression DACC-coated dressing was applied to reduce microbial load. Use of DACC led to decrease microbial load as demonstrated by a reduction in devitalised tissue, and progression of granulation tissue formation until epithelialisation was achieved within 4 months.

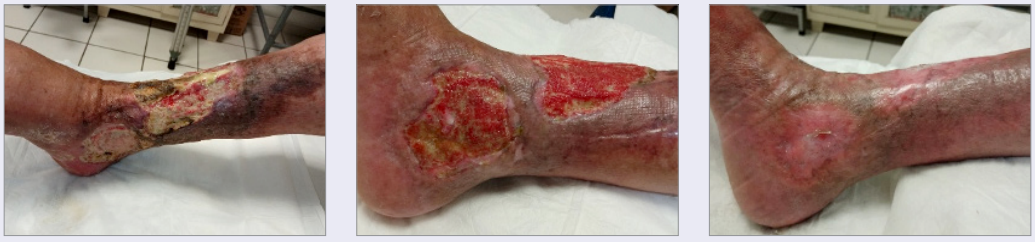
Week 0 | Week 3 | Week 15



Clinical Case 2: 63-year-old male patient with vascular ulcer.

Patient presented with vascular ulcer due to complications from venous insufficiency that has been ongoing for four months. He was admitted due to complications of venous insufficiency and presence of a vascular ulcer in the right tibia measuring 12 cm in length, 10 cm in width, and 0.5 cm in depth. There was a second ulcer measuring 7 cm in length, 6 cm in width, and 0.7 cm in depth, with a positive culture for *E. coli* and *K. pneumoniae*. Surgical debridement was performed every 96 hours in combination with the use of DACC-coated dressing and a compressive bandage. The wound showed progressive granulation tissue growth. Once the wounds were clean and granulating treatment with DACC was discontinued and healing was achieved in the following eight weeks with cotton gauze and paraffin dressings.

August | November



Clinical Evidence Keypoints

- Promoted wound progression in acute and hard-to-heal wounds
- Improvements during wound progression included reduced signs of inflammation, increased granulation tissue, re-epithelialisation

granulation tissue and re-epithelialisation. Clinical case examples of the use of DACC-coated dressing are shown in Clinical Cases 1 and 2: Reproduced with kind permission from: Catherine Álvarez Cruz, Policlínico de Cirugía Box de Curaciones Avanzadas de Pie Diabético, Hospital de La Serena EE. UU, Chile **[Case 1]**, and Eduardo Bustamante, SSM, Hospital General de Cuernavaca "Dr. Jose G. Parres", Cuernavaca, Morelos México **[Case 2]**.

The effect of DACC-coated dressings on pain management

Chronic wound-related pain is a significant issue for patients, with evidence suggesting that up to 70% of individuals experience moderate to severe chronic wound-associated pain (Leren et al, 2021), and up to 95% during wound management procedures (Tegegne et al, 2020). Dressing removal has been identified when patients experience the most pain (Cutting et al, 2013), with the suggestion that this pain is associated with trauma as a result of adhesion to the wound bed due to the dressing drying out (Hollingworth and Collier, 2000). The dressing material can negatively affect the level of pain experienced by patients during dressing change (Cutting et al, 2013),

Seventeen studies reported a response to pain in patients to treatment with DACC-coated dressings across a variety of wound aetiologies including surgical wounds (Bullough et al, 2012; Taylor et al, 2020; Mulpur et al, 2024), paediatric wounds (Ciprandi et al, 2022), leg ulcers (Kammerlander et al, 2008; Sibbald et al, 2012; Mosti et al, 2015), DFUs (Nielsen and Andriessen, 2012; Sibbald et al, 2012; Bateman, 2015), PUs (Kammerlander et al, 2008; Sibbald et al, 2012), and burn wounds (Jeffery, 2014; Bateman, 2015; Kleintjes et al, 2018). Mosti et al (2015) conducted a randomised comparative study in 40 patients with leg ulcers of various aetiology (venous and arterial ulcers) comparing DACC-coated dressing with a silver-containing hydrofiber. Although there was no difference between the two dressings, the authors reported a 38% reduction in ulcer-related pain in the DACC-coated dressing group at the end of the observation period on day 4.

A large (n=1232) retrospective assessment of the use of DACC-coated dressing in acute and chronic wounds found that the use of this dressing in paediatric and adult patients resulted in an alleviation of pain (as measured via visual analogue scale, VAS) at dressing removal after the first 2-5 changes (Ciprandi et al, 2022). Kammerlander et al (2008) conducted a 116 patient multi-centre study assessing the effectiveness of DACC-coated dressing on the management of wounds of varying aetiologies (largest proportion DFUs (22%)). The authors assessed tolerability of the dressing by patients at every dressing change (n=1150). A comparison of pain VAS scores at the end of the evaluation period indicated a marked improvement in pain symptoms during treatment. The proportion of patients experiencing no pain (VAS, 0) at dressing change increased from 52.2% to 83.5%, and there was a corresponding decrease in the proportion patients experiencing severe pain (VAS, 7-10) from 10.4% to 0.9%.

The reduction of wound-related pain (Hampton, 2007; Hardy, 2010; Bruce, 2012; Sibbald et al, 2012) and pain experienced at dressing change (Kammerlander et al, 2008; Pirie et al, 2009; Hardy, 2010; Bullough et al, 2012; Kleintjes et al, 2018; Cardilicchia and Todaro, 2024; Mulpur et al, 2024) were found to be a recurring outcome in the remaining studies where pain was assessed as part of clinical studies.

The effect of DACC-coated dressings on healthcare costs

The costs associated with treating wounds include the price of dressings, specialised wound care therapies (e.g. negative pressure wound therapy), healthcare professional visits for dressing changes, potential surgical costs, and associated costs of managing underlying conditions. In one study, patient care costs of an unhealed

Clinical Evidence Keypoints

- Reduction in levels of wound-related pain
- Reduction in pain experienced at dressing change
- Increased proportion of patients experiencing no pain at dressing change

wound were a mean 135% more than that of a wound that heals (Guest et al, 2017a). The primary cost driver of managing acute wounds was found to be hospital admissions and day cases, whereas the main driver for managing chronic wounds was drug prescriptions and total community staff costs (Guest et al, 2017b).

Wound infection can significantly increase cost of treatment (Guest et al, 2018; Costabella et al, 2023) due to factors such as extended hospital stays, additional medications (e.g. antibiotics), additional required surgical procedures, and more frequent dressing changes. The UK's National Institute for Health and Care Excellence (NICE guidance document (MTG55) in 2021 suggested a DACC-coated dressing (Leukomed Sorbact) should be considered as an option for the prevention of SSIs in post-caesarean and vascular surgeries where wounds are anticipated to have low to moderate exudate. Cost modelling demonstrated a reduced rate of SSI seen with using the DACC-coated dressing could potentially result in costs savings, saving the NHS up to £5.3 million per year for caesarean section surgery and up to £1.2 million per year for vascular surgery (NICE, 2021).

The effect on healthcare costs was described in 10 studies with all studies finding that the use of DACC-coated dressings had a positive impact on healthcare costs. Gueltzow et al (2018), using a Markov modelling approach estimated VLU progression for one year (n=297,507) showed that an increased use of a DACC-coated dressing reduced costs in both drug and dressing expenses, with the impact increasing over the course of 12 months. The use of DACC-coated dressings in 50% of target patients led to a higher number of healed ulcers and ulcers without wound infection within a year and lowered overall cost per patient. The audit data suggest that managing patients appropriately and preventing infection reduces the use of expensive antimicrobials and other dressings. Four RCTs exploring surgical wounds showed DACC-coated dressings were cost-effective (Stanirowski et al, 2016a; Stanirowski et al, 2019; Mahyudin et al, 2020; Magro, 2023). In one RCT, a study of 543 women undergoing elective or emergency caesarean section surgery found that a reduction in SSI rates in the DACC-coated dressing group (compared with the standard surgical dressing group) was associated by a lower total cost of SSI prophylaxis and treatment (1065 EUR vs. 5775 EUR) (Stanirowski et al, 2016a). The authors note the prolonged hospitalisation and additional nursing care, and systemic antibiotic treatment in the control group as reasons for the additional costs. Generalising these results to the UK's NHS, when UK unit costs were applied costs of SSI prophylaxis and treatment were 49.6% less in the DACC-coated dressing group compared with the standard of care group (Stanirowski et al, 2019).

Magro (2023) conducted retrospective and prospective audits to compare SSI incidence pre- and post-implementation of the use of DACC-coated dressing for the treatment of caesarean section surgery. Despite the higher unit cost of the DACC-coated dressing compared to the absorbent dressing used in the retrospective audit group, the reduction in SSI rates in the DACC-coated dressing group resulted in a total cost savings over 12 months of £234,784. This cost saving was because of the implementation of NICE's guideline on the use of DACC-coated dressing in SSIs (NICE, 2021).

Limitations and future directions

This review has several limitations. Although we reviewed 67 studies, only 11 of these studies were RCTs, and most of the studies were case series or case reports. There was also a high level of heterogeneity in the reporting of wound types, locations and outcomes but many studies lacked detailed descriptions of methodologies. There was also a lack of standardisation amongst the studies regarding the use of DACC-coated dressing for wound management. Many of the studies had small sample size and

Clinical Evidence Keypoints

- Positive impact on healthcare costs
- Reduced drug costs as well as costs associated with dressings
- Lower costs associated with infection prophylaxis and treatment

short follow-up durations. In addition to the variability among the studies, observer bias must be considered when assessing the effectiveness of DACC-coated dressings especially considering the number of case series and case reports. Although the evidence indicates clinical effectiveness of DACC-coated dressings, the limited quality of the evidence requires further clinical studies in support of the dressing's promising usefulness in the management of wound infection.

Conclusions

DACC-coated dressings are an important tool in the arsenal in the management of infection in wounds, including acute and hard-to-heal wounds offering a unique physical mechanism for the elimination of microorganisms from wounds that reduces the risk of antimicrobial resistance. This review summarised the clinical evidence for the effectiveness of DACC-coated dressings in reducing and preventing wound infection, and supporting healing, particularly in surgical site infections and hard-to-heal wounds.

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Enabling antimicrobial stewardship through the use of DACC-coated wound dressings

Introduction: Antimicrobial resistance (AMR) is a global health concern and as such treating infection is orchestrated using the five pillars of antimicrobial stewardship (AMS) (Wounds UK, 2020). In wound care, treating potentially infected or mildly infected wounds with antibiotics is now questioned and alternatives are sought wherever possible (Wounds UK, 2020). Historically, treating infections posed a major challenge for clinicians due to a limited understanding of microbes, and the lack of effective treatments, leading to high mortality rates. Since their introduction, antibiotics have revolutionised medicine, saving countless lives since their discovery in the early 20th century (Muteeb et al, 2023). However, the development and use of antibiotics is now being overshadowed by an alarming rise in antibiotic (antimicrobial) resistance. This has originated from the adaptability of microorganisms, partially driven by misuse and overuse of antimicrobial agents, especially antibiotics (Tang et al, 2023). Increased numbers of infections associated with AMR has resulted in patient suffering and rising mortality rates (Dadgostar, 2019; Ahmed et al, 2024). AMR is a worldwide problem and a focus of attention for the World Health Organisation (Ho et al, 2024). There is added concern that resistance may develop in the other groups of antimicrobial agents where resistance has been reported to antifungal agents (e.g. Candida auris) (Sanyaolu et al, 2022), and in some common viral pathogens such as influenza (Smyk et al, 2022). Topical antiseptics are widely applied to manage various infections, including those encountered in wound care including silver (McNeilly et al, 2021; Terzioğlu et al, 2022; Rippon & Rogers, 2025) and chlorhexidine (Buxser, 2021). As their use becomes more commonplace, it is essential to adopt a stewardship approach to guide the responsible use of agents, e.g. silver, iodine, and others. DACC dressings offer an alternative for treating infected or mildly infected wounds as there is little possibility of resistance developing because of its unique mode of action (Rippon et al, 2021). This unique mechanism of bioburden reduction reduces the unnecessary use of antimicrobials in wounds that have not been confirmed as infected. This chapter summarises how the mechanism of action of DACC-coated dressings can enable and promote the implementation of antimicrobial stewardship (AMS) in wound care.

Global Implications of AMR

In 2019, AMR caused 1.27 million deaths worldwide and was associated with nearly 5 million deaths (Antibiotic Resistance Collaborators, 2022). By 2050, it is predicted that as many as 10 million deaths a year may be attributable to AMR. In 2024 WHO published a Bacterial Priority Pathogens List (WHO, 2024) of antibiotic-resistant bacteria that pose the greatest threat to human health:

- **Critical priority group:** *A. baumannii* (carbapenem-resistant); *Enterobacterales* (third-generation cephalosporin-resistant); *Enterobacterales* (carbapenem-resistant); *Mycobacterium tuberculosis* (rifampicin-resistant).
- **High priority group:** *Salmonella Typhi* (fluoroquinolone-resistant); *Shigella* spp. (fluoroquinolone-resistant); *Enterococcus faecium* (vancomycin-resistant); *P. aeruginosa* (carbapenem-resistant); Non-typhoidal *Salmonella* (fluoroquinolone-resistant); *Neisseria gonorrhoeae* (third-generation cephalosporin- and/or fluoroquinolone-resistant); *S. aureus* (methicillin-resistant, MRSA)
- **Medium priority group:** Group A Streptococci (macrolide-resistant); *S. pneumoniae* (macrolide-resistant);

Haemophilus influenzae (ampicillin-resistant); Group B Streptococci (penicillin-resistant)

Several of the identified pathogens including MRSA, *P. aeruginosa* Enterobacteriacae are frequently isolated from wounds. Their increasing prevalence poses a significant concern, as emergence of these high-risk organisms in wound care could exacerbate treatment challenges and compromise patient outcomes.

Example Mechanisms of Antibiotic Resistance

Most pathogenic microorganisms have the capability of developing resistance to many antimicrobial agents. There are two main ways in which microorganisms can negate the effects of antimicrobial agents. The microorganism can prevent the antimicrobial agent (e.g. antibiotics) from reaching its target at a high enough concentration to have any toxic effects, or there is a modification or bypassing the target that the antimicrobial agent acts upon. The main mechanisms of resistance are outlined below **[Figure 4]**:

1. Efflux pumps: Bacteria use efflux pumps to actively expel antibiotics from the cell before they can act or lowering concentrations below levels that have a detrimental effect on the microorganisms. Additionally, mutations in bacterial DNA may result in elevated levels of these pumps, adding to the bacteria's resistance profile (Gaurav et al, 2023);
2. Reduced permeability: Bacteria alter membrane-bound porins to decrease membrane permeability and reduce antibiotic entry, limiting uptake of antibiotics by bacteria, particularly Gram-negative microorganisms (van der Heijden et al, 2016);
3. Enzymatic modification: Bacteria produce enzymes that chemically modify antibiotics or the targets of antibiotics, rendering them ineffective (Munita and Arias, 2016);
4. Enzymatic inactivation/degradation: Bacteria produce enzymes that chemically inactivate or breakdown antibiotics (Egorov et al, 2018)

The acquisition of resistance may be because of the mutation within the microbial chromosome or because of transfer of extra-chromosomal genetic material, known as plasmid transfer (Reygaert, 2018). In addition, in a wound, the production of a biofilm can also contribute to resistance towards antimicrobial agents (Muteeb et al, 2023). The protective matrix of the biofilm can hinder penetration of antimicrobial agents, making it difficult for them to reach and kill the microorganisms contained

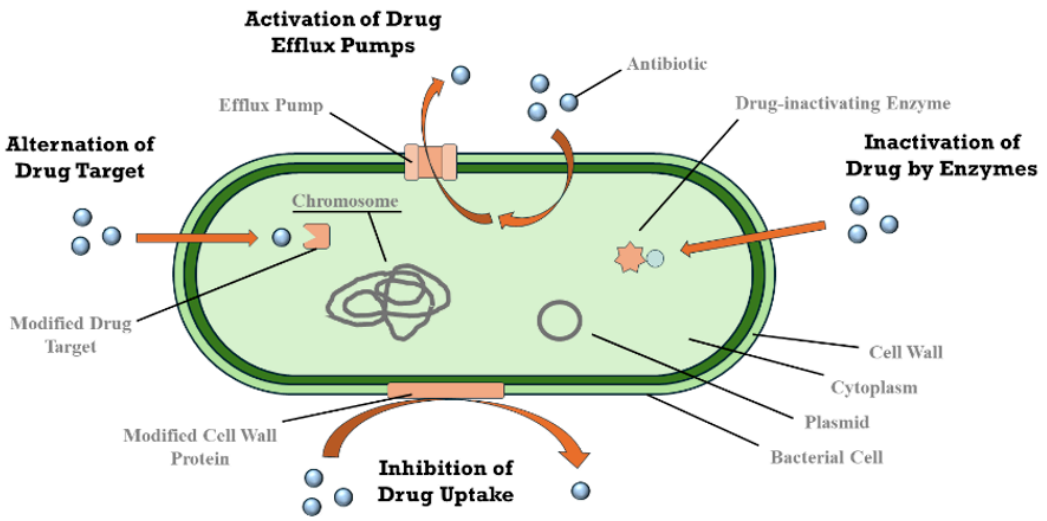


Figure 4: Mechanisms of antibiotic resistance

within. In addition, accumulation of antibiotic degrading enzymes such as beta lactamases can exacerbate the problem (Reygaert, 2018). The misuse and overuse of antimicrobial agents in wound care influences the reproductive success of microorganisms, leading to natural selection and an evolution of the bacterial population with AMR (Hasan et al, 2021). Optimal levels of antimicrobial agents must be used for treatment and management of infection in patients. If a biofilm is present in a chronic wound, then achieving this is unlikely unless there is some means of the antimicrobial agent penetrating the protective matrix of the biofilm (if used topically) or reaching the target site with poor blood supply to the area.

Importantly, reducing bacterial numbers by targeting intrinsic physical properties on microorganisms – such as the inherent hydrophobicity of bacterial cells walls – are unlikely to contribute to the development of AMR (Jeyaraman et al, 2025). It is noteworthy that the intrinsic hydrophobic properties of bacteria are important for interaction with host tissue (Doyle, 2000). If the same mechanism is targeted by a hydrophobic dressing, there is less likelihood of AMR; that is, a bacterium with high capability of interacting with host tissue (pathogenic) would also have high capability of interacting with a hydrophobic dressing.

Wound infection and AMR

Chronic wounds are polymicrobial with a diverse microbiota (Wolcott et al, 2016; Jneid et al, 2017; Liu et al, 2020; Verbanic et al, 2020; Uberoi et al, 2024) which may contain scattered or small clusters of planktonic microorganisms (Lichtenberg et al, 2024) but biofilms represent the dominant bacterial state in wounds (Malone et al, 2017; Lichtenberg et al, 2024). This microbial complexity has clinical implications. For example, one clinical study found that polymicrobial wounds are more likely to experience recurrent infections (Sidhu et al, 2019), and increased severity (Anju et al, 2022). These conditions may create a favourable environment for genetic exchange which may lead to AMR in chronic wounds (Jaffar and Jabber, 2024). Studies indicate antimicrobial resistant microorganisms present in chronic wounds (Tentolouris et al, 2006; Galkowska et al, 2009). Although the emerging resistance to antibiotics in wound care is of concern (Ousey and Blackburn, 2020; Rippon et al, 2021), the emergence of resistance to commonly used antiseptics is also of concern and under scrutiny (Panáček et al, 2018; Hosny et al, 2019; McNeilly et al, 2021).

Antimicrobial stewardship

To combat AMR, a key strategy is antimicrobial stewardship (AMS), a coordinated approach that promotes responsible and appropriate use of antimicrobials, including antibiotics. Defined as an "organisational or healthcare-system-wide approach to promoting and monitoring judicious use of antimicrobials to preserve their future effectiveness" (NICE, 2015), several healthcare organisations worldwide have actively developed AMS-centred guidelines and consensus documents (ECDC, 2023; Wounds UK, 2020). Collectively, these guidelines emphasise for the prudent use of antimicrobials by supporting key practices such as appropriate prescribing, systematic monitoring of antibiotic usage, and robust infection prevention measures. They highlight the critical role of education and training for healthcare professionals, the need to advance diagnostic capabilities, and the value of fostering multidisciplinary collaboration across clinical settings. AMS implementation has resulted in changes such as de-escalation of antimicrobial use (e.g. switching from intravenous to oral administration, or from broad- to narrow-spectrum antibiotics), as well as adjustments in dosage and treatment duration (De Waele et al, 2020; Umpleby et al, 2022). Several clinical studies (Roberts et al, 2017; Uçkay et al, 2019; Rippon et al, 2021) have reported beneficial effects of AMS on the treatment of wound infections and clinical outcomes.

AMR and stewardship today

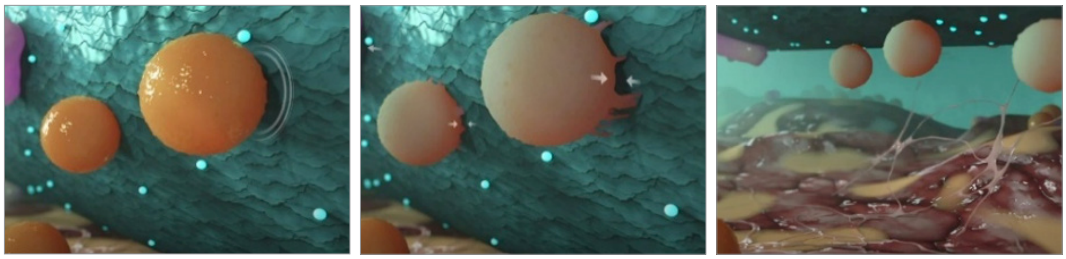
A literature review examining antimicrobial resistance (AMR) in humans analysed global data and applied predictive modelling indicated a positive correlation between AMR emergence and antibiotic consumption – particularly for pathogens classified by the WHO as critical or high priority (Oldenkamp et al, 2021).

Importantly, Allel et al (2023) suggests that reducing antibiotic consumption alone will not be sufficient to combat the rising worldwide prevalence of AMR. With the growing concern of antibiotic resistance, there has been a strong push to reduce the use of antibiotics, and to develop antibiotic alternatives (Willing et al, 2018). Some options in wound care include the use of antimicrobial agents such as iodine, silver, polyhexamethylene biguanide, chlorhexidine, and Manuka honey (Cwajda-Białasik et al, 2022; Maillard and Pascoe, 2024). However, some of these alternatives (e.g. chlorhexidine, zinc oxide, silver nanoparticles) may themselves result in the development of AMR (Buxser, 2021; McNeilly et al, 2021), necessitating caution (Willing et al, 2018; Nair et al, 2023). Dialkylcarbamoyl chloride (DACC) offers a novel approach to delivering antimicrobial action that does not appear to induce AMR (Jeyaraman et al, 2025).

DACC and its novel mechanism of action

DACC-coated wound dressings offer a novel approach to antimicrobial action using a physically binding and removing bacteria from a wound without relying on chemical antimicrobial agents. DACC-coated dressings' mechanism of action is based on hydrophobic interactions, which exploit the hydrophobic properties of some bacterial cell walls (Ljungh et al, 2006). Through hydrophobic interactions between these microorganisms and hydrophobic DACC, bacteria bind to the dressing surface without disruption of their cell walls, preventing the release of toxic elements such as endotoxins (Rippon et al, 2021; Rippon et al, 2022; Susilo et al, 2022; Rippon et al, 2023). The bound bacteria are subsequently removed during dressing changes, as summarised in **Figure 5**.

This physical mechanism of action contrasts with traditional antimicrobial dressings that rely on chemical agents including silver or iodine. Because DACC does not contain or release bactericidal substances, it avoids cytotoxicity to host cells and supports undisturbed wound healing (Ljungh et al, 2006; Morgner et al, 2022; Ortega-Peña et al, 2022). Furthermore, by not exerting bactericidal pressure, DACC-coated dressings do not promote microbial resistance, addressing a key concern in AMR (Andersson and Hughes, 2017). The reduction in selective pressure is central to limiting the emergence of AMR (Chadwick and Ousey, 2019). **Figure 6** summarises the advantages of DACC-coated dressings.



Bacteria naturally bind and anchor to the unique DACC surface

Bacteria are irreversibly bound, and growth is inhibited. Development of bacteria or fungal resistance is not expected

Bound bacteria, fungi and endotoxins are safely removed

Figure 5: Schematic representation of the mechanism of action of DACC-coated dressings

Enabling antimicrobial stewardship through the use of DACC-coated wound dressings

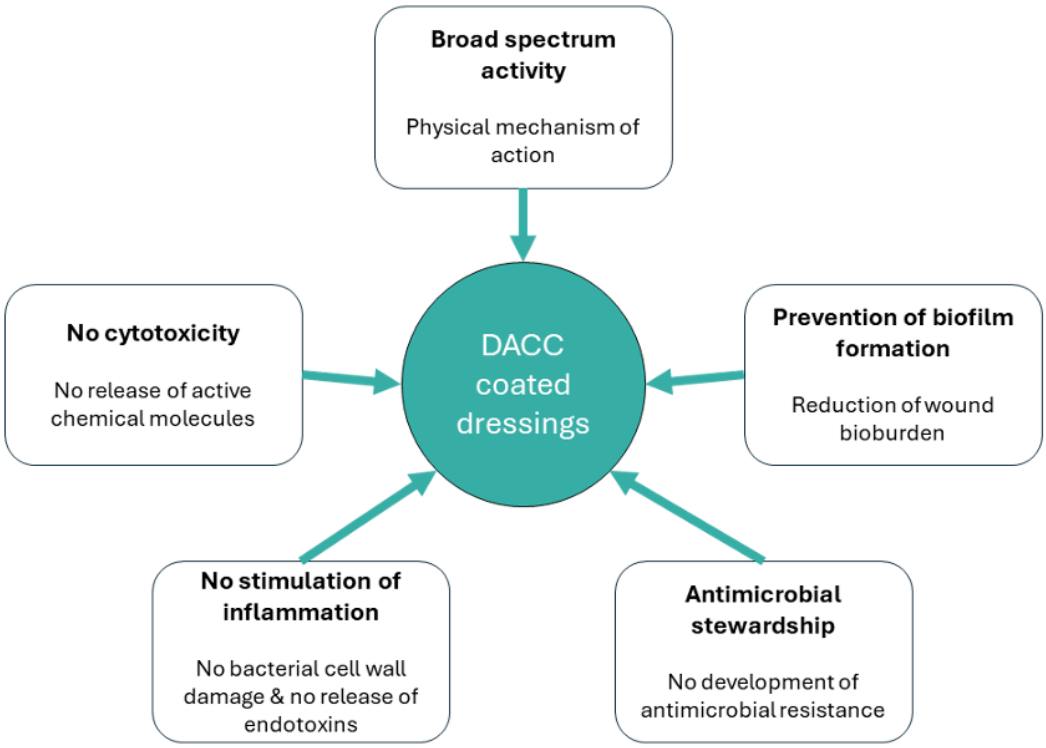


Figure 6: Advantages of DACC-coated dressings (adapted from Jeyaraman et al, 2025)

DACC-coated dressings and AMS Keypoints

- Most pathogenic microorganisms have capability of developing antimicrobial resistance
- No evidence of resistance development of physical mechanism of antimicrobial action of DACC-coated dressings

The inclusion of DACC-coated dressings into AMS strategies is supported by multiple attributes:

- Minimises the risk of AMR due to physical nature of mechanism of action (Ousey et al, 2023)
- Clinical effectiveness (Totty et al, 2017; Wijetunge et al, 2021; Jeyaraman et al, 2025; Rippon et al, 2025b)
- Effective against a wide spectrum of microorganisms (Geroult et al, 2014; Husmark et al, 2022; Ortega-Peña et al, 2022), including WHO priority pathogen list microorganisms (Ronner et al, 2014; Rosana et al, 2009; Husmark et al, 2022), antimicrobial resistant microorganisms (Ronner et al, 2014; Cooper and Jenkins, 2016; Husmark et al, 2022) and biofilms (Brackman et al, 2013; Larkö et al, 2015; Meredith et al, 2023)
- Non-toxic to eukaryotic cells involved in wound healing (Falk and Ivarsson, 2012; Morgner et al, 2022; Ortega-Peña et al, 2022)
- Supports wound healing progression (Kammerlander et al, 2008; Mayhudin et al, 2020; Romain et al, 2020; Sebayang and Burhan, 2024)
- Scores highly in patient satisfaction (e.g. reduced pain experienced, wearing comfort) (Mayhudin et al, 2020; Seckam et al, 2021)
- Cost effectiveness (e.g. potential cost savings associated with reduction in incidence of infection) (Stanirowski et al, 2016a; Gueltzow et al, 2018; Stanirowski et al, 2019)

Although direct evidence linking DACC-coated dressings to a reduction in AMR is currently limited (Jeyaraman et al, 2025), both in vitro and clinical evidence have demonstrated their ability to reduce bacterial load and prevent infection. The novel physical mechanism of action should reduce the risk of AMR by avoiding selection pressure.

Limitations and future directions

A limitation of this mechanism for the physical mode of action of DACC-coated dressings is the requirement of supporting clinical evidence, and studies are needed to assess the impact of DACC use on microbial resistance patterns over time.

Conclusions

The continued development of AMR across all health sectors (including wound care) is still a growing problem. The use of alternative treatment strategies for managing wound infection is an imperative. This requires the development of new treatments that will not induce AMR, whilst also being clinically effective in treating a wide range of bacteria that are evolving to circumnavigate a wide range of antibiotic/antiseptic treatments. DACC-coated dressings appear to provide this alternative with extensive evidence that supports its successful use in preventing and treating infection in a variety of wounds.

Antimicrobial action against microorganisms results in the reduction of microbial burden in wounds. The mode of action of antimicrobial agents differs depending upon the underlying mechanisms. **Figure 7** highlights the key differences between chemically based antimicrobials (e.g. antibiotics) and the physical mode of DACC highlighting how, reductions in microbial load through active (chemical) antimicrobial action can have detrimental consequences (e.g. increase in AMR, potential for systemic septic reactions). Antimicrobial action provided by the physical mechanism of DACC can assist in reducing the development of AMR whilst maintaining effective infection treatment and prevention.

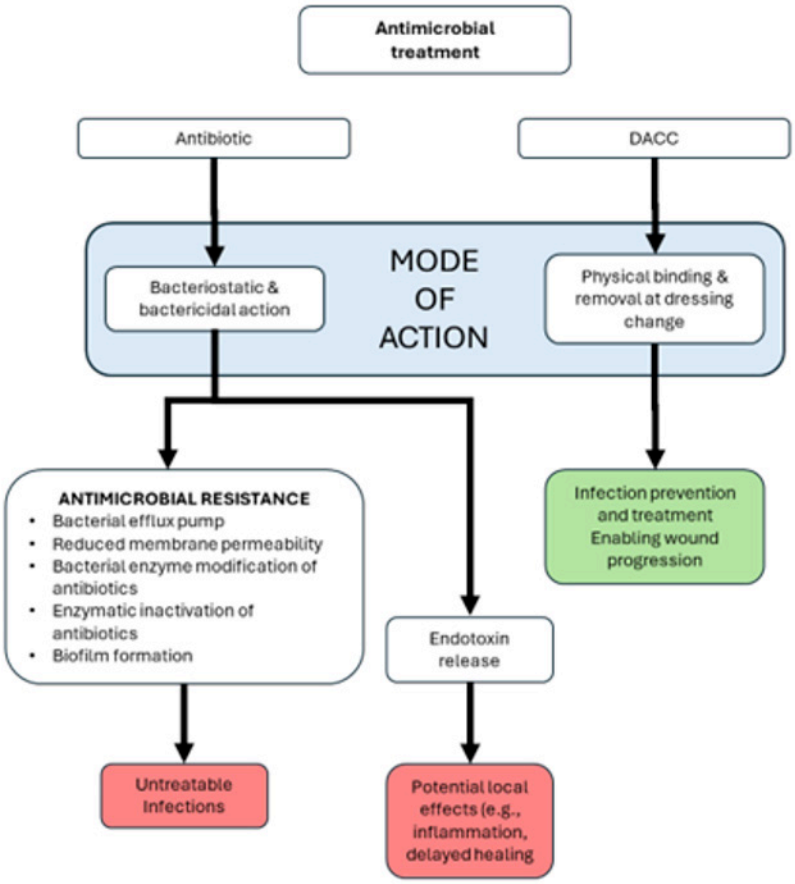


Figure 7: Antimicrobial mechanism of action: antibiotic vs. DACC

Concluding summary

The basis of all clinical decisions and treatments should be supported by Evidence Based Medicine (EBM), defined by Sacket et al (1996) (p71) as *"...the conscientious, explicit and judicious use of current best evidence in making decisions about the care of the individual patient. It means integrating individual clinical expertise with the best available external clinical evidence from systematic research"*. The use of EBM in wound care is well-established and has been supported by the National Wound Care Strategy Programme (2024). This Position Document has presented and explored experimental and clinical evidence underpinning use of DACC-coated wound dressings to prevent and treat infections, thereby promoting wound healing progression in both acute and chronic wounds.

The reviewed evidence highlights that DACC-coated wound dressings effectively reduce infection rates and prevent infections in surgical wounds. Additionally, the findings support their use in managing wound infections in neonatal and paediatric patients. Notably, the evidence emphasises the cost effectiveness of DACC-coated wound dressings in treating infections in hard-to-heal wounds, including chronic wounds such as venous leg ulcers, diabetic foot ulcers, and pressure ulcers, as well as wounds assessed as having biofilm. Given the rising threat of antimicrobial resistance (AMR) and its significant impact on global healthcare and mortality rates, developing alternative strategies for managing wound infections has become crucial. DACC-coated dressings offer a promising solution, with robust evidence supporting their effectiveness in preventing and treating infections across a range of wound types.

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