2018

Education Plan to Empower Wound Care Nurses for Evidence-Based Practice

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This is to certify that the doctoral study by

Patricia Stevenson

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
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Walden University
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Abstract

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MSN, Aspen University, 2011

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Project Submitted in Partial Fulfillment of

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Abstract

Nonhealing wounds can claim thousands of lives and costs billions of dollars each year, and nurse-led wound clinics are becoming necessary to fill a gap in care for patients with wounds. Even among certified wound nurses using evidence-based clinical protocols, key considerations of care are being missed. Therefore, this project was focused on developing and validating a new biofilm education module for certified or certification eligible wound care nurses. The aim of the module was to boost clinical assessment knowledge and improve patient outcomes. Benners skill acquisition model informed the development of this project. The design of the project also included a panel of expert wound care nurses using a 5-point Likert questionnaire to provide feedback on the biofilm education module, including evaluating the content, context, relevance, and use in the practice setting. Descriptive anaysis provided evidence to inform the revision of the education module. Results of the Likert questionnaire ranged in mean score from 4.6 to 5.0, indicating there was strong agreement among the panel members that the education module met the objectives. The completed education module has been presented to the organization leadership for future implementation. This project supports positive social change by improving nurses' preparation to provide early clinical assessment, intervention, and definitive biofilm eradication treatments, ultimately improving patient outcomes.

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Dedication

I dedicate this project to my husband Gary who left to be with the LORD and who sacrificed our time for me to complete this program, we will redeem it in HEAVEN. And to my wonderful children Belinda and Aaron who have encouraged and supported me through all the trials and tribulations of juggling family, work, and school. Telling me that they knew I could ‘do it’. To God I give the glory for being able to finish this project and dedicate all I do to the service of HIS KINGDOM. I love you all.

Acknowledgments

Every day of my life is a Blessing, given by GOD as HIS promise. Despite the struggles, discouragement, and sometimes despair I may experience, my life steps are ordered of GOD and HE sustains me. I give all the glory and praise to HIM as he has brought me through another journey. As the author and finisher of my FAITH, HE has once again shown me HIS support and encouragement even in the valley of shadows we have experienced these last four years. It is my heartfelt joy to serve HIM with the new awareness and knowledge HE has revealed of HIS plan through this DNP program. Additionally, I wish to thank my friend Sue DeVilliers for mentoring and encouraging me through my practicum experience. I would also like to thank my colleague and friend Rodney Baccus for being available when I needed an extra proofing or encouragement to not give up. I also recognize Don Ayers, my lifelong friend and mentor who reminds me of the 30-thousand-foot view and keeps me grounded in the purpose. Lastly, to each of my Walden University faculty members who have contributed to this DNP project, I would like to communicate my sincerest gratitude for living up to the truest form of mentoring and guiding me through this process.

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Section 1: Nature of the Project

Introduction

Since the early 2000s, when patient outcomes became a metric for measuring the quality of care, translating evidence-based research into bedside practice has been a challenge for nurses. For many nurses who graduated before 2003, incorporating evidence into current practice was not a part of the curriculum. Changes in practice, including changes in technology and evolving evidence have led to a need for a method of translating evidence into nursing practice (Majid, 2011). Additionally, there is a direct correlation between nurses using evidence-based medicine and patient outcomes (American Nurses Credentialing Center, 2014).

This Doctor of Nursing Practice (DNP) project was focused on developing nurse continuing education based on knowledge gaps for certified wound nurses. The purpose of this DNP project was to develop an evidence-based staff education module to improve the wound care nurse's knowledge of biofilm. Biofilm is defined as a self-sustaining aggregate of microorganisms that emit an invisible three-dimensional sticky polymeric substance that embeds into many surfaces including wounds (Wolcott, 2010). Characteristics of biofilms include mixed flora organisms including gram-positive and gram-negative bacteria, fungus and spores; with pathways that prevent interference from internal host defenses and external topical products that may inhibit biofilm growth and seeding (Wolcott, 2010). Based on organizational quality improvement (QI) and monthly data reports, there was a need to provide updated education on nursing assessment of wounds for infection regarding the impact of biofilm in wound infections. Providing a

biofilm education module functions as a mechanism for nurses in the organization to learn advanced knowledge about emerging wound care evidence and make translating changes to practice more successful.

The setting of this DNP project was a small wound management company in South Central United States that manages approximately 10 multistate wound care programs. During initial meetings with the CEO and key stakeholders of the organization, concerns over the numbers of wounds that progress to infection-focused administrative resolve to improve staff education. Many of the social stigma and detriments of having a nonhealing wound can be transformed through nurse education (Deming, 2000). Not only by reducing the economic impact of timely nursing interventions preventing wound progression to amputation but also through the evolution of healthcare delivery as nurses evolve in professional wound care practice (American Nurses Credentialing Center, 2014). The current education modules did not reflect new evidence concerning biofilm but staying current with wound care requires new staff education. As a part of the organization's QI project, identifying biofilm before it progresses to infection was a top priority. It has been over 2 years since the last wound care education occurred, which may have contributed to variances in patient outcomes with infection, as several patients had progressed to some degree of an infected state after a negative wound culture. Administration believes that this may be in part to other influencers such as staff variances, staff turnover, patient volume, multitasking by nursing staff, and increased patient acuity, but a gap in knowledge regarding wound infection pathogenesis and

overlooking clinical signs of infection if wound cultures were negative represents knowledge deficits.

Research has shown that there are identified clinical predictors of treatment failure especially progression of wound infection (Gardner, 2009). Wound infections left unaddressed are strong predictors of negative wound outcomes. For example, patients who failed to heal 58% from the baseline at 4 weeks had an approximate healing rate at 12 weeks of only 9% (Lipsky, 2007; Sheehan, 2006). Infection is considered a pivotal predictor of healing outcomes and can be impacted by undiagnosed or untreated wound biofilm. Research from several sources has shown that the source of over 90% of wound infections begin as a biofilm (Attinger, 2012; Petrova, 2012). Additionally, research has indicated that bacterial biofilm should be considered as equally important as nutrition and perfusion (Hurlow, 2016). Research continues to clarify the role nurses play in diagnosing and managing wound infections, now specifying nurse assessment indicators for the presence of biofilm (Brown, 2018). This project supports positive social change by improving nurses' preparation to provide early clinical assessment, intervention, and definitive biofilm eradication treatments, ultimately improving patient outcomes.

Problem Statement

Local Nursing Practice Problem

According to the Institute for Health Care Improvement, health care should be timely; unintended waiting is a system or knowledge deficit and compromises patient outcomes (Institute of Medicine, 2001). Furthermore, health care delivery should involve continually seeking to reduce waste and increase adherence to clinical best practice.

Research has indicated that among clinical contributors associated with failure to meet wound healing trajectories, critical aspects of assessment have a severe and progressive impact on wound healing. The practice problem for this study was that the organization's wound care nursing staff lacks awareness of subtle signs and symptoms of biofilm that can lead to serious wound infections, delayed healing, and treatment failures. Improving nurse clinical assessment knowledge of biofilm can improve patient healing outcomes. A lack of current staff education of biofilm effects in chronic wounds affects the patient and wound assessments, treatment choices, and predisposes patients to significant mortality and morbidity from escalated infections (Hurlow, 2016). The development of a current biofilm related staff education module can help to improve the safety, care, and outcomes for patients.

Current QI results support immediate changes in assessment and clinical care to mitigate suboptimal nurse performance and patient outcomes. Because the organization employs nurses who have varied levels of experience in wound care beyond initial certification, the organization believes that nurses need to receive additional continuing education that is current and reflects an evidence-based care continuum.

Local Relevance of the Need

Through an internal QI program, the organization verified that patient outcomes are not reaching acceptable benchmarks for healing and may represent focused educational needs. Reviewing routine monthly data reports, the CEO identified several critical performance variances confirming the results of the QI project. The organization's top identified needs are:

1. Patients wounds are progressing to infected despite negative bacterial swab cultures.
2. High use of advanced therapy products without a healed outcome.
3. Patients are arriving to clinic without off-weighting in place.
4. There is a failure to repeat reperfusion follow-up Doppler tests within 30 days of revascularization procedures.

In addition to the organization in this study, several variances have failed to meet national wound care standards (Fife, 2012). The practice issue for this DNP project was to develop a nurse continuing education on biofilm that bridges a current gap in knowledge for the organization. Because most of the managed clinics are nurse-run, either with wound certified or certification eligible nurses, ongoing nursing education needs became a focus for organizational leadership and key stakeholders. To reach internal benchmarks for healing and patient safety, the organization recognized that education as a priority should be elevated in the perspective of leadership and organizational driven activities.

Significance for the Field of Nursing Practice

The DNP project can improve nursing knowledge regarding biofilm and wound healing and shed light on the broad impact biofilm has on wounds and wound healing. With renewed emphasis on a barrier to wound healing that compares to ischemia, nurses will be prepared to address the nuances of biofilm growth, regrowth, and disruption with knowledge that leads to better nursing care and patient outcomes. Within the organization, objectives for the biofilm training will establish the tone for nurse education moving forward for this organization. Beyond updated information on assessing infection

related to biofilm, developing an education module that improves nursing assessment can contribute to higher patient, client, and staff satisfaction. The new module promotes an expert clinician standard that certification implies.

According to Benner's skill acquisition in nursing model of novice to expert, nurses who obtain specialty education such as wound care receive relatively little to no clinical precepting to the new role, which compromises care and places the staff at a disadvantage (Benner & Wrubel, 1982a; McEwen, 2011). Benner's model can apply to the integration of established technical knowledge as well, as tenure does not eliminate a nurse from the novice role. Despite experience, there are still gaps in care related to skipping or overlooking critical steps strategic to healing patients with wounds, which can also make translating evidence into clinical practice slow and leave organizations fiscally at risk (Spranca, 1991). In health care nurses are often the first to recognize the impact of practice change in patient conditions. Being current with pertinent field specialty information produces a sense of professionalism and effectiveness for patients, organizations, and nurses alike (Stevens, 2013). This DNP project further supports the benefits of advanced wound care education for specialty wound care nurses.

Purpose

Meaningful Gap-in-Practice Addressed

The purpose of this DNP project was to develop an evidence-based staff education module to improve the wound care nurse's knowledge of biofilm. The practice focused question driving this staff education project was: What factors are most important to include in a newly developed education program regarding biofilm knowledge for wound

care nurses? Improving staff education is seen by the organization as the optimal way to strengthen strategic initiatives including improve patient outcomes, foster a climate of ongoing learning, and improve staff competency (see Smith, 2013). This project was focused on a biofilm educational program to augment current wound care knowledge and was based on research that provides the staff with a subset of critical information pertinent to up-to-date findings on biofilm. For this organization, current wound care metrics regarding several wound care areas have decreased and have become priority for an educational intervention. Through the future implementation of this focused biofilm education module, the organization may decrease the numbers of patients progressing to infection despite negative lab cultures. The biofilm education module objectives are:

1. Examine the role of nurses in biofilm treatment.
2. Describe the role of biofilm in wound healing.
3. Compare biofilm bacteria from planktonic bacteria.
4. Arrange in order the biofilm life-cycle.
5. Examine the role of biofilm in different aspects of health care.
6. Explain how biofilm protects bacteria.
7. Describe how biofilm creates evolving bacterial resistance.
8. Investigate the paradigm shift in current literature for biofilm management.
9. Explain the mechanisms of biofilm response to debridement and regrowth.

The ability to adopt evidence into practice is considered a priority for organizations and nurses, but there are many barriers to evidence-based medicine (Tacia, 2015). Annual wound care recertification requires wound care related continuing

education but without problem specific requirements (American Board of Wound Management, 2014). As the science about biofilm reveals an expanding impact linking biofilm and chronic disease, the knowledge gap also increases regarding how to assess and manage biofilm (Omar, 2017). Data from the DNP project site document that nurses may lack awareness of subtle signs and symptoms of infection that can lead to serious wound infections, delayed healing, and treatment failures. The goal of the DNP staff biofilm education module is to improve: (a) clinical awareness of appropriate assessment and treatment steps, (b) nursing care in complex healing situations, and (c) patient outcomes.

Nurses lacking a proper awareness of and assessment knowledge of biofilm impact patient progression to infection if not addressed (Omar, 2017). This knowledge gap correlates with Benner's theory that nurses need further post certification education; therefore, the development of an advanced educational module addresses a significant assessment problem with chronic wounds. Given the elevated level of skill required to perform effective wound care, evidence supports that focused continuing nursing education can help to compensate for lapses in judgment, the noise of distractions, variations in experience, and the overload produced by juggling clinical responsibilities (Health Research & Educational Trust, 2013).

In addition to the gap in knowledge on biofilm, several factors of concern were the lack of knowledge needed to translate evidence into practice, limited access to current, understandable evidence, and time management. Researchers from Ohio State University have reported that less than half of the nurses surveyed agreed that evidence is

implemented, and less than one-third agreed that there was mentoring to assist with evidence translation into bedside care (Ford, 2012). The consensus among the nurses was that staff nurses were less likely to receive the tools, education, and resources for research implementation. Perceptually, nurses agreed that an organization that is committed to ongoing staff education is also committed to professional growth, using up-to-date research, and quality practice. When continuing education is seemingly not a priority, patient care falters (Ford, 2012; Thomas Hess, 2014).

Another concern is that the organization uses an internally developed wound assessment tool based on key healing indicators for nursing assessment; however, parameters associated with infection represent overt infections and are not inclusive of covert infections that begin with biofilm (see Edmiston, 2016; Percival, 2015). Although not all wounds become infected, the risk of infection increases when bacterial counts are high, the patient is immune compromised by disease or medications, and the care is inconsistent or poor (WoundSource Editors, 2016). Biofilm is the predecessor of most infections and is a barrier to wound healing that is not identified through routine culture methods (Omar, 2017).

According to the CEO, the organization has set a benchmark for healing at a threshold of 88%; this coupled with other quality indicators such as documentation of off-weighting and the performance of certain clinical assessments provides the foundation for improved patient care through their QI program. The CEO continued to explain the rationale of setting healing outcome goals as an indicator of possible quality of care issues. For example, advanced therapy use without a healed outcome can suggest

improper work-up and assessment, poor patient selection, or noncompliance. The ability to measure higher level quality issues through the marker of healing provides the organization with a faster focus on potential areas needing improvement. Nationally there is reluctance to determine care by rates of healing because healing is not always possible in some patients and represent a poor standard for quality of care indicators (Fife, 2012); but according to the CEO, the organization believes tracking overall healing rates and healing by wound type is a method to uncover deeper quality issues. By learning updated assessment parameters of wound assessment, the nursing staff at the DNP organization can adhere to the standards established for nurses certified in wound care.

Potential to Address the Gap-in-Practice

Improved and updated staff education can address gaps in nursing practice through improved knowledge and identifying and explaining aspects of assessment that are currently missing from patient care. Often nurses are faced with science, methods, and ideas that require additional education. Without up-to-date methods of treating and managing nonhealing wounds, patients are at risk for significant barriers to healing. Nurse continuing education is a bridge between high-quality care and patient outcomes; use of additional supplemental instruction supports the early adoption of emerging research and promotes high-quality patient care.

Historically, smaller organizations like the setting for this project have relied on the experienced nurse to teach complex techniques and concepts to the newly certified or certification eligible nurses. Nurses taught other nurses by passing experiential knowledge on to other nurses with little to no formal continuing education, which

supports Benner's theory of how nurses learn (Benner & Wrubel, 1982a). Additional knowledge relies on sporadic vendor product information and training, self-directed learning, and past experiences to facilitate research to practice. The lack of ongoing relative wound care education impacts current care, and organizational leadership and nursing educators struggle with how to bring evidence to the bedside with few resources. Many small organizations are stretching resources with no identified funding beyond a nurse educator for continuing education and fall short of the need for focused supplemental training. The organization in this study believes that the development of a focused biofilm education reinforces patient care, nurse professional goals, and organizational needs (see Kress, 2018).

It is no longer possible to expect nurses to perform competently without ongoing additional education. The need for more specialty-specific training is especially true among wound care staff where the volume of patients with wounds is escalating, costs for nonhealing wounds are skyrocketing, and technology changes frequently (Nussbaum, 2018). Poor patient outcomes for patients with chronic wounds manifest through the social and economic impact on the United States. For example, over 6.5 million people suffer from chronic wounds with an annual cost ranging from $28 to 32 billion dollars annually for Medicare recipients alone, and it becomes a point of staff dissatisfaction when patients do not heal (Hurlow, 2016; Nussbaum, 2018).

Typically, organizational orientation provides foundational wound care information, organization-specific review of policies, procedures, and patient goals; however, more advanced education is needed. Staff education protects patient safety and

assists nursing staff in meeting multifaceted and dynamic standards of care (Corbett, 2012; Zeller, 2014). But in smaller organizations, emerging research implementation is difficult because of confusion over which evidence would improve the whole organization, lack of awareness of current trends in the specialty, limited access to current, understandable evidence, and time management for bare-minimum staffing. Additionally, the technological advancements in wound treatments requiring awareness and engagement have become problematic for wound care nurses (Thomas Hess, 2014). Studies confirm that as nurses become busier, patients become more complex, and technology evolves, an emphasis on regular and planned education is needed (American Nurses Credentialing Center, 2014).

Another factor indicating the need for more staff education is that the education gap becomes more apparent once nurses become specialized. Although certification implies self-directed continuing professional development, many nurses find they rely on accessible often loosely related continuing education to meet continuing education requirements for recertification. These efforts do not always meet needs for growth both professionally and for the organization. Examples of tools to assist nurses in following established protocols are available and can significantly impact nurses, patients, and organizations, but the gap between what is known and how actions are adopted requires not only ongoing evidential education but methods to help nurses integrate knowledge into practice (Green, 2005). Instances of slight changes in treatment that may seem unrelated and harmless can contribute to a delay in healing for chronic wounds and lead to potentially profound consequences (Sheehan, 2003).

According to the American Nurses Credentialing Center, it is also essential to evaluate the impact of ongoing or continuing nurse education on patient outcomes (American Nurses Credentialing Center, 2014). Research confirms that focused specialty education can prevent variations in patient care which translates into improved safer patient care and better patient outcomes (Hales, 2008). Research also indicates that even skilled professionals require analysis driven education to provide expert up-to-date patient care and reduce the consequences of knowledge gaps. The benefit of evidence based wound care supported by research has a positive impact on patients, staff, and organizations (Majid, 2011).

The complexity of health care, combined with an emphasis on evidence-based outcomes driven practices, requires innovation in methods to eliminate inconsistent care and produce better patient outcomes (Hales, 2008; Health Research & Educational Trust, 2013; Majid, 2011). As in other specialty fields, the volume and complexity of implicit and explicit wound care knowledge are filled with avoidable failures with the volume of information often exceeding ability to deliver care without education. Focused and translated information is necessary; the knowledge of established evidence from peers, journals, and conferences is not enough to advance wound care nurses' practice.

Nature of the Doctoral Project

Sources of Evidence

Sources of evidence for this project included contemporary evidence that is leading practice in the field of wound care. The literature searches included peer reviewed

journals and websites dedicated to wound healing such as *Journal of Wound Care, Skin & Wound Care*, *Journal of Wound, Ostomy*, and *Continence Nursing, Wounds, Ostomy and Wound Management* as well as the Infectious Diseases Society of America, CINAHL, Medline, and PubMed. Current evidence from these sources was used to develop a comprehensive curriculum focused on biofilm. Other sources of evidence included stakeholders providing feedback on the development of the biofilm education program and from the staff nurses who participated in the program.

Summarized Approach to Organize and Analyze the Evidence

The evidence found in the literature search was used to produce an inclusive curriculum using the spaced learning theory that promotes understanding of biofilm and create an understanding that translates into practice (see Kelley & Whatson, 2013; Kornell, 2010). Findings were organized according to relevance to the assessment and treatment of wound biofilm. Information most relevant to outpatient wound care was analyzed for inclusion into the final education module. The design of this project included a panel of expert wound care nurses using a 5-point Likert scale questionnaire for formative and summative review of the biofilm education for content, context, relevance, and use in the practice setting. Descriptive anaysis provided information to inform the revision of the education module. The complete education module was presented to the organization leadership for future implementation.

Significance

Identification of Stakeholders

Recognized stakeholders for this project included wound care clinic nurses, wound care patients, patient families and caregivers, organization administrators, and nursing education. Stakeholders understood the current gap in practice indicated that key elements in the assessment process are either not being completed or the signs and symptoms of biofilm are being missed. Research on factors that delays wound healing is forefront in medical research for patients with wounds (Costerton, 1999; Metcalf, 2013; Omar, 2017; Phillips, 2010; Wolcott, 2015). The clinical spotlight has been redirected from generic wound infection concepts to those rooted in biofilm (see Phillips, 2010). Biofilm is a constant in the human microbiome and has been recognized as the most likely cause of post-operative device infections, gingival associated sternal wound infections, and is now identified as prevalent in over 90% of all nonhealing wounds and accounts for billions of health care dollars (Fife, 2012; Petrova, 2012; Wolcott, 2016). Among leadership of the organization and the nursing staff, there has been a growing concern that new employees, program expansion, and personal practice preferences have weakened the organization's healing goals. There are also several consequences the organization realized could impact the future of the organization such as a reduction in site expansion, legal risks associated with poor patient trajectories, and loss of current revenue for canceled management contracts. Without a well-educated, efficient nursing staff, contracted facilities see the expense of managed services as avoidable and accomplished internally without a management company. The participation in this project

for the organization was to identify education that helps the nursing staff become experts and clinically astute, fiscally manageable, scalable, and a unit that a single nurse educator can oversee and manage. The most significant issue of this project is the patient, which relates to an economic impact of healing wounds. The desired outcome of this project has been to facilitate organizational goals establishing care that is consistent with evidencebased wound care practices and internal benchmarks. As an outcome of this project, the nursing staff who provide patient care will be accountable for providing complete assessments including an added awareness of biofilm at each patient visit.

The leadership team, comprised of the nurse educator, the medical director, and the CEO is responsible for formulating a plan for wound care nursing staff education module implementation. The design and approach of this education will include content review and module approval, communication with and the training of the nursing staff, monitoring and reporting of training compliance, and ongoing monitoring for outcomes under scrutiny for patients who progress to full infection.

Potential Contributions to Nursing Practice

Understanding how biofilm develops and the mechanics of how biofilm presents barriers to healing is now a foundational concept among leaders in wound care. The potential contribution to nursing practice includes promoting current biofilm education that advances comprehensive assessments of patients and their condition at each patient visit. Additionally, the project can provide an understanding of effective treatments and how to optimize choices in treatments, preventing consequences from undiagnosed infection.

Potential Transferability to Similar Practice Areas

Biofilm forms in host situations where conditions are not ideal such as in patients with diabetes and other autoimmune diseases, subclinical nutrition, poor blood flow, and compromised immune systems. Biofilms are responsible for 65 to 80% of all human infections (Jamal, 2018; Lebeaux, Chauhan, Rendueles, & Beloin, 2013). Biofilm begins to develop within minutes to hours after bacterial inoculation and become established within hours to days (Di Domenico, 2017; Phillips, 2010). Further, even in its earliest states, biofilms show protective mechanisms for bacteria forming communities that are protective and exchange DNA and communicate within their domain to prevent eradication (Omar, 2017). It is established that much antibiotic resistance is the result of biofilm (Chadha, 2014).

Developing an education about biofilm can benefit other clinical areas. Common infections are now recognized to be biofilm-based: surgical site infections, cardiac endocarditis, clostridium difficile infections, heater coils in surgical bypass equipment, dental plaque, and recurring otitis media and sinusitis is biofilm-based (Lebeaux et al., 2013). By improving understanding of what biofilm is, how it forms, and treatment options, other clinical areas can also play a part in biofilm management.

Implications for Positive Social Change

Beyond organizational concerns, wounds represent a burden to the patient, family, and society (Maddox, 2012). The physical and emotional components of poor wound healing are not addressed in this project; however, the negative implications of having a nonhealing wound have wide personal and social facets. Socially, wounds represent a

large consumption of resources, represent a loss of confidence by patients in healing, mirrors health failure to patients, and erodes financial stability (Health Research & Educational Trust, 2013). Nurses feel responsible when patients do not heal or suffer extended consequences from a nonhealing wound. The stigma of having wounds and the soaring costs of wounds can be reduced through more education on biofilm (Fife, 2012; Maddox, 2012). Positive social change occurs through increased awareness. By providing a mechanism through education of direct care givers, the organization can raise awareness of the devastation associated with biofilm and the nature of biofilm infections. Education can alleviate potential gaps in care, improve patient outcomes, and alert other health care providers about biofilm.

Summary

This project is designed to bridge the knowledge and action gap between nursing knowledge and patient care by identifying focused biofilm education that meets specific knowledge deficits and encourages nurses to move from awareness to procedural application. The aim of staff education includes recommendations to sustain staff education along with research, which can prevent delays in care and possible adverse patient outcomes (Armstrong, 1998). Although care can vary between clinical sites, and there are limited standards of care associated with wound healing, stakeholders reached a consensus that education is the priority.

Interactions between key stakeholders, staff, organization leadership, and the perspectives of emerging research and evidence-based practice, fiscal intermediaries, partner hospitals, patients, and communities were all factors in developing this project.

Collaboration and critical thinking relevant to the goals of the organization guided this project from the perspective of patient safety and nursing care with the eventual goal of meeting benchmarks and financial growth. Subsequently, the use of this education plan template can be applied to other education needs of the organization. Section 2 further provides the rationale for this project, the importance to nursing practice, the theoretical concepts, framework, and theories for the DNP project.

Section 2: Background and Context

Introduction

After QI audits at the study site generated from observed clinical activities, a corresponding administrative data report revealed wound healing outcomes had failed to meet benchmarked standards. The CEO and nurse educator compared the QI results and the data reports, leading to a concern with uninformed nursing wound assessments. As part of a broader effort to identify trends in care, this organization uses a wound care specific web-based clinical management system, which provides the ability to produce regular monthly reports on parameters without chart review as well as ad-hoc reports based on perceived need for identified clinical areas. Findings based on reports from this management system led to the need to develop an evidence-based staff education module to improve the wound care nurses' knowledge of biofilm. Further, emerging research has confirmed the risk of biofilm. As organizational benchmarks slipped below acceptable markers, leadership posed the question: What factors are most important to include in a newly developed education program regarding biofilm knowledge for wound care nurses?

In this section, I identify relative concepts, models, and theories that advised this doctoral project, incorporating foundational nursing theory, and those who intellectualize the process of learning. This section includes an explanation of the relevance of this project to nursing practice, the local background and context of the practice problem, my role as a DNP student, and the role of the organization's project team. I have also included connected terms specific to the topic of the education.

Concepts, Models, and Theories

Rationale for Project Concepts and Theories

Proficient practice requires nurses to work from a framework of professionalism and knowledge. Nursing is an evolving profession based on the premise that nursing is the sum of patient protection, promotion of effective health care, optimization of health, prevention of injury and illness, alleviation of suffering, and patient advocacy (American Nurses Association, 2001). Additionally, nursing involves promotion of patient safety, which involves focused education to reduce ambiguity, clarify prioritization questions, and to remind nurses of critical assessments and activities during patient care.

Nursing theory is the cornerstone for building a safe practice (Wills, 2014). Supported by the Institute for Health Care Improvement, certain parameters are needed such as timeliness, as unintended waiting is a system or knowledge deficit and affects patient safety and positive outcomes (Institute of Medicine, 2001). Adherence to clinical best practices should be efficient, reduce waste, and increase adherence to known clinical standards. However, evidence supports that nurses face many challenges in the delivery of health care with escalating expectations of doing more in less time (Burger, 2010).

Primary Writings by Key Theorists

According to Benner's skill acquisition in nursing model, nurses who receive special education such as wound care get minimal to no precepting to the new role, which compromises care (Benner & Wrubel, 1982b; McEwen, 2011). This inconsistent support for post certification focused education contributes to gaps in care such as overlooking critical steps to healing patients with wounds. Used as a guiding practice for nursing staff

with knowledge gaps, the Benner skills acquisition in nursing model can alleviate many current barriers to staff education. Further, using this model to reinforce problem-solving skills can facilitate how nurses process information, and reestablishing clinical education can improve team communication and consistency of care and reduce complications associated with wounds despite barriers to care (Brixley, 2005).

In addition to Benner's model, the contextual model for this education module addresses the integration of knowledge and adoption or action. The knowledge-to-action (KTA) framework developed by Graham et al. (2006), which identifies seven phases from problem identification through sustained knowledge use, was chosen for its application to action. The KTA model can minimize the evidence–practice gap that affects translating evidence into practice. Wound care staff at the host organization vary in experience from 1 to 12 years, but all levels experience frustration when gaps in care are identified and new knowledge is presented and applied. Using the KTA framework for bringing established knowledge or research into practice, a two-part process with multiple steps will allow the organization the familiarity of a repetitive process for reevaluation and improvement as well as fostering the translation of evidence into practice in an organized manner (Field, 2014; see Figure 1).

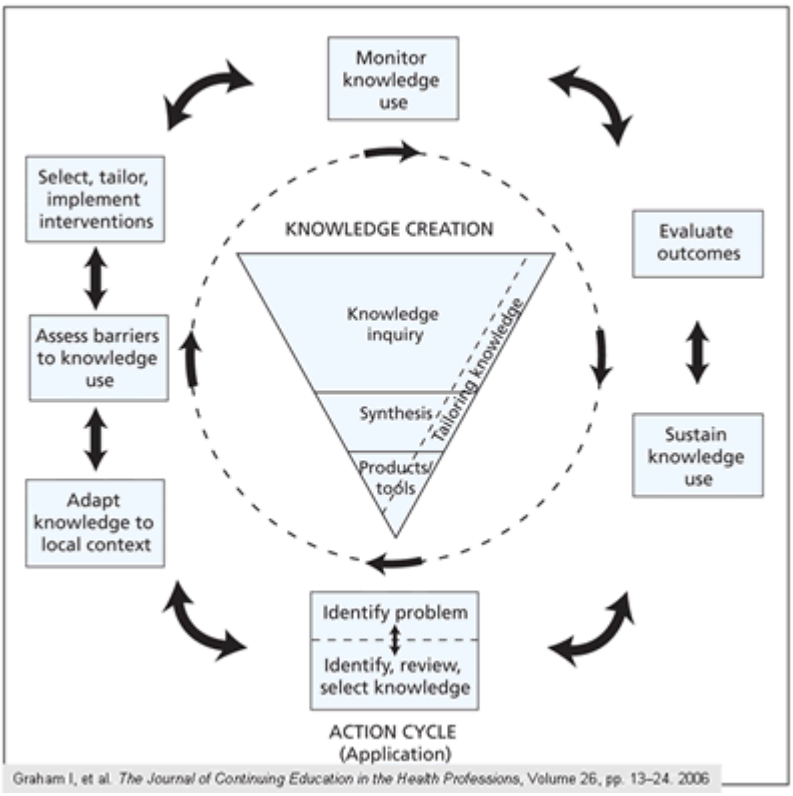


Figure 1. Knowledge to action cycle.

Interpreting Benner's theory that nurses begin as novices and progress through a continuum to expert as information and circumstances change places all nurses as novice nurses at repeated points in their careers. Recognizing the nature of nursing and the reality of changes in evidence require a framework to influence a systematic yet a dynamic means of translating evidence into practice. Thus, the KTA framework assisted with organizing knowledge and the process of moving that knowledge into action or in this case improved patient and wound assessments for biofilm. The steps for the KTA framework include:

1. Knowledge Creation, through research, creating a final product that meets the needs of the end users; and

2. Action Cycle, which identifies the problem, known research, barriers and successes of the information, planning and implementation, and finally, monitoring and adjusting (Graham et al., 2006).

Each of the processes steps overlap and relate to each other beginning with an understanding of the needs. Steps for this staff development project are to translate a staff education into clinical practice for organization-wide use. The organizational goal is for future staff education to become institutionalized to establish the culture of high-quality care as the norm.

Relevance to Nursing Practice

The Historical Problem in Nursing Practice

Information overload is a concern in nursing (Graham et al., 2006). Ways to advance education for nurses in the context of real-world constrictions for time and the evolution of evidence-based practice is needed to assist nurses in considering care and treatment options during every patient visit. It is no longer possible to standardize, routinize, and delegate activities that are integral to the critical thinking of the wound care specialist. Several challenges are evident in the function of current clinical nursing. Time is compressed during work hours, distractions from focused care have become common, and the demand of families, and social obligations are mentally and physically exhaustive.

One of the main barriers to care is the amount of distractions during patient care visits. Interruptions in patient care occur as often as every 6 to 7 minutes, distracting nursing focus away from direct care (Burger, 2010). As nurses become accustomed to

necessary multitasking, opportunities to miss vital clinical aspects of care are increasing. Missed treatment or care modalities that may seem harmless individually, when overlooked contribute to a delay in healing for nonhealing wounds and lead to potentially profound consequences (Sheehan, 2003). Regardless of organizational obstacles, ongoing pressure by many organizations including the Institute of Medicine and Healthy People 2020 expect measures that minimize the gaps in quality care and demonstrate improvement in patient outcomes (Institute of Medicine, 2011a; U.S. Department of Health and Human Services., 2015). Further, in recognition of the impact on nurses today, in 2006 the Institute of Medicine reported that the circumstances in which nurse's work are less than ideal and cause distracted thinking, even during times when the focus is critical.

These concerns with distractions were also evident at the study site. Interorganizational official benchmark reports indicated variances in previously stable wound care metrics. Previous observations by the nurse educator had also identified that intra visit interruptions, a lack of awareness of clinical pathways, and straying from best practice were becoming more common, which predisposes patients to delayed care and poor healing outcomes (see Han, 2017). The organization has recognized that reinforcement of care steps improves the patient's quality of care. As one CEO observed, the days of a "zombie" approach to wound care are over and wound care is more than applying dressings (Zeller, 2014). For example, patients with wounds should achieve specific healing timelines that are predictive of a healed outcome, but without reinforcing measures such as pressure removal, recognizing and treating infection, and mitigating

edema, patients fail to improve as projected (Sheehan, 2003). By providing a mechanism for staff to learn and adopt more advanced assessment and treatment modalities, patients experience a better outcome. This means that nurses need to reevaluate how wound care is provided and question practice that is not producing positive results (Corbett, 2012). For instance, once certified, ongoing education is generalized to the functional aspects of wound care, such as dressings, wraps, and topical products and global issues of nutrition, edema, and off-weighting the wound (Thomas Hess, 2011). Elements that promote wound healing depend on the experience and focus of the provider, clinical alerts in electronic health records, or after-the-fact case review, all of which can contribute to delays in treatment, variations in care interventions, and a healed wound outcome.

Current State of Nursing Practice and Recommendations

Research confirms that clinical continuing education can prevent variations in patient care, which translates into improved patient outcomes. Research also supports that skilled professionals should participate in ongoing clinical education (Green, 2005; Hales, 2008). The goal of the organization was to reaffirm the use of education to bring a more advanced awareness of evidence to the bedside. Increased awareness and knowledge means a more astute nurse and improved assessments for patients with wounds. The complexity of health care, combined with a focus on evidence-based practices, requires innovation in methods to eliminate mistakes and produce more control over patient outcomes (Hales, 2008; Health Research & Educational Trust, 2013; Tokede, 2014). As in other fields requiring precision, the volume and complexity of wound care knowledge

are filled with avoidable failures and often exceeds the nurse's ability to deliver care correctly, safely, or reliably without more specific education.

The context of this project was to develop a staff education module that provides a method for the organization to enhance the knowledge of the more experienced nurse but provide progressive education to the inexperienced staff. Based on an interview with the CEO, the organization has recognized that the consequences of lapsing continuing education may have affected patient care, nursing professional satisfaction, and the organization's strategic goals. When evidence-based concepts are applied, it improves workplace satisfaction for nurses and inspires the desire for further education (Bedell et al., 2003; Levin, Fineout-Overhold, Melnyk, Barnes, & Vetter, 2011). Built on research and concepts of adult education, continuing education centering on evidence-based practice is considered appropriate for nurses in specialty practice and can prevent errors of omission and commission and support good judgment (Spranca, 1991).

Based on the significance of evidence-based practice, I developed an evidence-based staff education module that reflects up-to-date information as a blueprint to improve nursing assessment for biofilm in patients with wounds. The long-term plan is for this education module after review and validation by a panel of experts to become a component of initial clinical orientation for new clinical staff and become a portion of their internal QI program schedule repeated by staff at least annually. Ongoing monitoring of the impact of the education will be evidenced through improved metrics of QI evaluations, monthly and ad hoc data reports on patients with infections and meeting healing trajectory goals. In a climate where medical errors are a significant cause of death

and disability, and acts of omission can contribute to poor patient outcomes, improving the practice of health care should be a focus (Institute of Medicine, 2000; Spranca, 1991).

Previous Strategies and Standard Practice

Patient assessment is the cornerstone of caring for patients with wounds. A literature search confirmed that the focus of becoming a certified wound nurse is assessment and treatment (Lozano-Plantonoff, 2015). Effectiveness is the evidence of appropriate assessments and management, without which, care is perceived as haphazard, fruitless, or wasteful (Institute of Medicine, 2011a). Ongoing wound care education is mandatory for certified nurses, but not prescriptive. Biofilm is not a new phenomenon however, the recognition of biofilm's impact on wounds has been evolving. Until the past three or four years, there were vague comparisons of the differences between bacterial loads and biofilm. Until the development of microscopic evaluation, biofilm was undetectable. If swab cultures were negative there was an assumption that the wound was not at risk of progressing to an infected state. In the presence of a negative wound culture, nursing assessments focused on other parameters such as nutrition, edema, and other key wound assessment elements. According to one author, with the recognition that there are nursing assessment parameters relevant to biofilm, nurses can now include this knowledge into daily practice (Hurlow, 2016).

As new science has emerged revealing the nature and substance of biofilm, the attention has been refocused on the structural component which is amplifies the potential biofilm has for blocking wound healing. The development and implementation of a

biofilm staff education module is hoped to be used as a tool to improve the delivery of high-quality specialty care and increase nurse awareness of new science and knowledge.

How the Present Doctoral Project Advances Nursing Practice

According to one article, evidence-based practice is not as easy as understanding the research and knowing how to apply the information (Green, 2005). There have been multiple speculations questioning why clinical practice lags behind the research, often by several years (Green, 2005; Ford, 2012; Tacia, 2015). Aspects of practicing evidence-based medicine that crosses professional lines often focus on the element of pertinence. If the evidence applies to a current need, then it translates easily into everyday practice; if the information is random, it is not applied. The rationale for this DNP project is it advances nursing practice, relevant to the majority of patients, and under scrutiny both professionally and at the organization. There is a reason for the change. The DNP education project for biofilm education will improve patient care, patient outcomes, and professional satisfaction. Education that is designed to resolve a practice gap will form an alliance between the organization and nursing staff with accountability on both parties. This is echoed throughout areas where infections are developed, transmitted, or treated. The problem of biofilm is germane to everyday practice across many health care arenas.

Local Background and Context

Summary of Local Evidence on the Relevance of the Problem

Small rural hospitals, the main client type for this organization, depend on the wound management company to improve the client's reputation, ability to care for patients in their home community and generate revenue that was previously lost to larger

urban hospitals. If the organization fails to live up to contractual obligations either perceived or in fact, it translates into a reduction in site program expansion for the project organization, legal risks associated with poor patient trajectories, and loss of current revenue for canceled management contracts.

A successful business model relies on well-educated, proficient nursing staff. If contracted facilities see the expense of managed services as avoidable and easily carried out internally because the model fails, they will cancel contracts and provide the care internally. The participation in this project for the organization is hoped to identify education that sets the nursing staff apart as experts and clinically astute, building an education model that is fiscally manageable, scalable and one that a single nurse educator can oversee and manage.

The most significant issue of this project is the patient, and economic impact healing wounds promptly connote. The desired outcome of this project was to facilitate organizational goals establishing care that is consistent with evidence-based wound care practices and internal benchmarks. As an outcome of this project, the nursing staff who provide patient care will be accountable for providing full assessments at each patient visit.

Institutional Context

The DNP project organization manages wound care under contract for several small hospitals. The average monthly census for all patients seen varies from 400 to 600 patients per month over the 10 managed sites. Patient wound etiologies range from diabetic foot ulcers, arterial and venous ulcers, to pressure ulcers (Skrepnek, 2017).

Occasionally, there are nonhealing wounds from animal bites, motor vehicle accidents, and cancer/radiation wounds. The average patient age is 61 years old and is mixed almost equally between female and male. Most patients have at least one comorbid condition that is an influencing factor in the wound healing process, making the patients complex to manage. The organization is committed to providing the highest quality patient care and feels a part of each community location. The strategic vision of the organization is to engage more underserved communities to provide care normally reserved for larger metropolitan areas on a local level with the same or better quality of care.

Federal Context Applicable to the Problem

Recent proposed changes in quality driven reimbursement have made hospitals and providers more aware of how tightly patients' outcomes and performance of the organization will be blended. With reimbursement changes beginning as early as 2011, wound care professionals are having to adjust business models previously based on volume to align with value-based care incentives. Payments, beginning in 2019 will be based in part on quality, practice improvement activities, and aggregate total cost of care not reimbursed by item or on a procedure (Schaum, 2017). Focus is adjusting from a procedural based process in assessing patients with wounds to one that emphasizes early diagnostics and evaluation and management. Clinical efficacy will be the front and center driver for patient care. Having a wound center staff that is knowledgeable about subclinical processes such as biofilm, before they erupt into full-blown sentinel events will have wide-spread financial implications for organizations that depend on hospital contracted services such as wound management companies.

Role of the Doctor of Nursing Practice Student

Professional Context and Relationship to the Doctoral Project

I believe that scholarship within the profession of nursing has many aspects; research and discovery, education and teaching, clinical practice, and the translation of the relevant evidence into nursing practice. Specifically, I feel the role of the DNP prepared nurse is to take these roles to a higher level. Integrating nursing knowledge, and knowledge gained from other disciplines in a salient scientific fashion while advancing patient care, patient safety, and the profession of nursing is the expectation of the DNP prepared nurse (American Association of Colleges of Nursing, 2006).

Facilitating nursing professional growth through advanced nursing education is one role of the DNP nurse. Beyond the option as faculty, there are opportunities to redefine how adult learners receive information and to construct educational activities that are cutting edge, functional, and impactful, guiding realistic practice change. Use of new technology using simulators, open online courses, and video is changing how education in specialty care is constructed and implemented. As I move into the DNP role I can foresee the challenges to delineate systems of care, refocusing nursing success on useful and meaningful information, and be representative of the full scope of professional nursing work. As a DNP prepared nurse, I will be a change agent to elevate the expertise of nursing from many perspectives; from working with bedside nurses, and administrators to formative roles in industry, policy making, and academia.

I look forward to maturing into a DNP nurse that offers a well-rounded background to change the way care is delivered to patients. Through the process of

developing this staff education project, I have realized that I will benefit from the learning experience as much as the staff. Developing successful education is audience dependent. I realized through personal experience the impact biofilm plays in the health of patients and our surroundings. As a nurse providing education for a research and development company, my goal is to improve patient health and health care outcomes. This project has allowed me to expand my knowledge and give me the opportunity to help bridge the gap between research and the bedside.

Role in the Doctoral Project

The role I have in this DNP project has been to analyze the need and establish the biofilm staff education for the organizations wound care staff for use across all sites of service. Literature that is evidence-based was used to facilitate the development of the biofilm education module. Researching the evidence and developing the education module has allowed me to impact the professionalism of the nursing staff, promote high-quality, safe patient care, and provide the organization with opportunities to expand. As I evolve into my DNP role and improve my ability to help nurses translate content into bedside care is an experience I can build upon.

Motivations

The primary motivation for this project is the impact biofilm has had on my family personally. I have been a certified wound care specialist since 2002 and have seen the devastation from unchecked infection. Professionally I have known that I had used every tool available without success, but intrinsically knowing that there was something missing, something we were not aware of. With the emerging information over the past

five years regarding the affect biofilm has on wound healing and the causative effects it has on literally hundreds of other health care areas I understand a nurse's perception of biofilm as a contributing factor to poor outcomes. Now with new knowledge I will be able to transfer the subtle and hidden nature of biofilm through education so that practice can change. True to Benner's theory, I realize nurses all are expert as some aspect of patient care but that we can all become novice nurses as new information becomes available. My role as a DNP nurse will reach beyond educator to one of a mentor in the life-long learning process.

Potential Biases and Ways of Addressing Them

Any project has the potential for bias and varies by project type and study model or design. Being aware of personal biases is part of being a professional nurse, understanding the source of the bias and what triggers it can influence the possibility of bias. Although opinion is in the background, education should be factual and grounded in science, supported by research. In consideration of the potential bias of opinion, facts must be separated from opinion for a successful project.

Role of the Project Team

The Use of a Project Team

For this project, the project team consisted of the CEO and organizational leadership as well as a panel of expert wound care nurses, and myself. As the project developer, it is important that I knew the present knowledge base of the panel members regarding biofilm and wound infection, most of the members will have taught wound care in some capacity. I have benefited from the experience applying nursing theory, models

of education, and concepts in nursing practice. This DNP project will facilitate nursing professional growth, promote ownership in the pursuit of evidence-based medicine, and contribute to positive patient care.

Summary

Nurse-led wound clinics are becoming necessary to fill a gap in care experienced by patients with wounds (Weldon, 2008). Even among wound care certified nurses, who use evidence-based clinical protocols, critical considerations of care are being missed. Research supports innovative ways to inspire nurses to assess specific care and treatment options during every patient visit (Hales, 2008).

Research confirms that using focused clinical education can help nurses avoid variations in care that can contribute to delayed healing in patients with wounds. Supporting the concept of focused specialty education after certification is evidenced by Benner's Skill Acquisition in Nursing Model theory of novice to expert. There is a growing awareness that nurses who receive specialty education such as wound care, receive relatively little to no clinical precepting to the new role which compromises care (Benner & Wrubel, 1982a; McEwen, 2011). This awareness combined with the knowledge that technology and evidence are published almost monthly amplifies the need for ongoing research and knowledge-gap education. Further, emphasis on a cohesive application of current standards and practice is needed to establish nursing education goals within the organization. Empowering nurses with ongoing specialty education, not only protects patients from out-of-date care, but can help to compensate for varied levels of nurse experience, clinical distractions, and issues such as overcrowded clinics while

still providing a mechanism for a smooth transition of unfamiliar information or evidence into clinical patient care (Benner & Wrubel,1982b).

The aim of this DNP project has been to provide a method to bridge a knowledge gap in nursing practice by developing a focused biofilm staff education module; the module encouraged evidence-based wound and patient assessments. Section 3 details the methods used to collect and analyze the evidence for this project.

Section 3: Collection and Analysis of Evidence

Introduction

Literature supports the use of post graduate education to improve patient outcomes, especially for patients with elevated health risks. The triad of nurse empowerment—education, environment, and autonomy—has been reinforced by articles indicating that the most effective framework for patient care is to develop this triad so nursing staff can accept and apply expanded decision-making responsibilities (Fullam, 1998; Macphee, 2012). This requires current information applied by a nurse in a health care setting that educates and empowers nursing decisions, especially when nurses become certified.

The purpose of this DNP project was to develop an evidence-based staff education module to improve wound care nurses' knowledge of biofilm. Using focused education can prevent clinical inertia (i.e., the failure to escalate treatment based on evidence) and increases knowledge applied to clinical practice. Formulating clinical practice, education-focused questions, and identifying the impact of advanced evidence-based education can serve as a template for nurses who have attained higher levels of training. Identifying biofilm is one aspect of care for patients with wounds that shows how advanced education can circumvent preventable events such as exacerbated systemic infections and infection-initiated amputation. While agreeing with the value of clinically developed education, focused education as a tool for improved patient care has been a challenge to the organization in this study. With a single wound care educator who also completes all quality processes, preparing and delivering educational activities has become difficult. In

Section 3, I iterate the practice focused question, provide sources of evidence, and how evidence was collected and analyzed to promote the appropriate application to the practice-focused question. A complete description of the nature of the data, there relevance to the practice problem, and the validity of the data collection process are also presented.

Practice-Focused Question

After evaluating current wound care practice, not progressing to positive wound healing outcomes may be because of overlooking key clinical aspects of care. The practice questions for this DNP project was: What factors are most important to include in a newly developed education program regarding biofilm knowledge for wound care nurses? The purpose of this DNP project was to develop an evidence-based staff education module to improve the wound care nurse's knowledge of biofilm.

Clarification of the Purpose

Bridging the gap in knowledge for wound nurses on new research aligns with the purpose of this biofilm staff education module. The KTA education cycle guided the development and will guide the implementation of this education through knowledge acquisition and the translation of knowledge into action (Graham et al., 2006). The steps in the biofilm education module development include:

1. Needs identification
2. Discuss needs with organizational stakeholders/organizational leadership
3. Research to identify current evidence-based practice

4. Literature findings will be organized according to relevance to the assessment and treatment of wound biofilm information most relevant to outpatient wound care will then be analyzed for inclusion into the biofilm education module
5. Discussion of identified information and education objectives with organizational stakeholders
6. Develop the education through an iterative review process using a formative meeting to review the draft education module and a summative evaluation (Likert scale questionnaire) with a group of expert wound care nurses (defined as holding wound care certification or eligibility).
7. Finalize the staff education module and present to organization A formative and summative descriptive analysis was used to guide revisions and to describe and demonstrate the development of this education module.

Sources of Evidence

The sources of evidence for this project included industry examples of different methods of providing continuing education and its usage and rationales, health care use of different delivery methods for education benefits and biases, current wound care standards of care, and key word searches. Strategies for obtaining the evidence included reviewing published peer-reviewed studies and Internet searches to identify other health care entities and specialties that currently use novel methods for staff education to alert staff to possible gaps in a protocol or critical steps. Additional sources of evidence

included input from the panel of experts who reviewed the education module and gave feedback through the Likert questionnaire.

Relationship of the Evidence to the Purpose

Though continuing education for nurses is a customary practice, advanced education for wound care is still a comparatively new phenomenon (Thomas-Hess, 2011). Nurses certified in wound care are expected to seek self-directed continuing education each year; however, much practice information is not translated quickly into forums that support easy-to-access nursing continuing education. Organizations wishing to stay in the lead using research supported evidence-based practice must be proactive in developing internally sponsored education. Education needs are amplified when there are data to support that if wound care nurses fail to remember core elements of care and omit important assessments for patients with wounds, wound healing is extended, total visits to heal are extended, more advanced therapies are needed, and healing trajectories are inconsistent (Thomas-Hess, 2011). Utilizing current research on the assessment and treatment of biofilm for initial module development and through feedback from the panel of experts, the wound nursing staff education module can provide the education wound nurses need to provide safe and effectual patient care. By providing a method to incorporate up-to-date focused clinical education, timely healing, fiscal strength, and positive outcomes can be promoted.

Evidence Generated for the Doctoral Project

Participants

The participants for this project included the CEO and key stakeholders of the organization and a panel of experts to refine and inform the biofilm educational module objectives. These panel of experts were selected because of their status as certified or certification eligible wound care nurses. The expert panel nurses have various levels of pre-existing knowledge of wound infections and biofilm.

Procedures

An initial meeting took place with the CEO and key stakeholders of the organization for approval of the biofilm educational module objectives. Any requested revisions were made during this meeting. The biofilm educational module was developed using all previously described data sources and a process of formative and summative review. A Likert questionnaire was used for the panel to evaluate the biofilm education for content, context, relevance, and utilization in the practice setting. The formative review took place after initial development of the educational module was completed and post Institutional Review Board (IRB) project approval number was received. The expert panel of wound care nurses were provided the educational module and the questionnaire to record their anonymous review responses. After the initial review was completed recommended revisions were made. Descriptive analysis was conducted on the formative and summative questionnaires to inform the revision of the education module. The complete education module was presented to the CEO, nurse educator, and director of clinical services of the organization for final approval and future implementation. All

participants completed provide Questionnaire results anonymously. The expert panels five participants had two panel seats, for balance, three nurses are from outside of the organization that were submitted to the organization and approved to participate.

Analysis and Synthesis

Through an iterative development process, formative and summative responses to the developed educational module were incorporated using recommendations collected using the Likert scale questionnaire for both the formative and summative phases. The questionnaire provided descriptive data to inform the ongoing development of the biofilm education module to ensure that it is meeting the stated objectives and for content, context, relevance, and utilization in the practice setting.

Using the Likert questionnaire, each expert reviewed the content of the module to determine if the content: (a) raises awareness of current wound care practice meeting the module objectives, (b) emphasizes the use of evidence-based wound care, (c) increases staff expertise about the subject, (d) is grounded in key assessment parameters, and (e) if the education module is appropriate for novice and experienced wound care nurses.

Procedures to Assure the Evidence Integrity

In compliance with the DNP manual titled *Staff Education Project* and the Walden University DNP project guidelines to protect the rights and welfare of human subjects, I submitted application for project approval prior to starting data processes. The Walden University Institutional Review Board (IRB) project approval number is # 10-05-18-0410196.

Summary

The organization believes that nursing education is a shared staff and organizational duty. Nurses may seek continuing education that meets personal needs; however, the organization has adopted the concept of organizational education that will augment the organizations strategic directives as well. The purpose of this DNP project has been to develop an evidence-based staff education module to improve the wound care nurse's knowledge of biofilm. Ultimately the goal will be to expand the knowledge of wound care nurses in the organization and to improve patient outcomes. The impact on healing will be determined by the organizational thresholds of appropriateness and benchmarks set by the organization. A simple, biofilm staff education module was developed and presented to the organization to address the organization's priority educational improvements.

Section 4: Findings and Recommendations

Introduction

Wound care nurses in the outpatient clinics managed by a regional wound management company in the Southwest are not assessing wounds for the presence of biofilm and are missing key clinical clues. The purpose of this DNP project was to develop a biofilm staff education module for nurses to increase awareness of the symptoms of biofilm and reduce patient progression to wound infection. The practicefocused question was: What factors are most important to include in a newly developed education program regarding biofilm knowledge for wound care nurses? Findings from this DNP project reinforced the development of an evidence-based practice

education on biofilm, which will bridge a gap in nurse knowledge and improve patient care and safety. This project is relevant for nursing practice and has the potential for new and remedial education on biofilm to other care settings.

Overview

It is important to merge knowledge, quality, and new functions in nursing (Institute of Medicine, 2011b). Nurses seeking to improve care can develop initiatives that involve new evidence-based practice through realignment of education and curriculum (see Stevens, 2013). In addition, specialty certification benefits the patient, nurse, and employer or organization and indicates a commitment to professional development, dedication to a changing environment, and validation of an entry level of knowledge (Cary, 2001). As health care becomes more complex, ongoing specialty education has been shown to reduce patient, nurse, and organizational exposures to risk, fostering personal growth and work satisfaction (Cary, 2001). This is important for wound care because as the recognition of biofilm increases, work continues to organize knowledge about the visual and indirect clinical aspects of biofilm, especially in the outpatient wound care arena (Hurlow, 2015). Under-recognition of subclinical signs and symptoms of biofilm may contribute to poor wound healing hidden in the inflammatory pathway that can culminate in profuse infection (Gardner, 2009).

I used information from current evidence-based recommendations to develop an inclusive curriculum that promoted understanding of biofilm, which informs nurses' knowledge and can improve patient outcomes (Snyder et al., 2017). This education plan was presented to clinical leadership to optimize biofilm wound assessment and guide the

use of appropriate dressings and treatments for biofilm. The biofilm staff education module includes information and strategies on how nurses can:

- Examine the role of nurses in biofilm treatment
- Describe the role of biofilm in wound healing
- Compare biofilm bacteria from planktonic bacteria
- Arrange in order the biofilm life-cycle
- Examine the role of biofilm in different aspects of health care
- Explain how biofilm protects bacteria
- Describe how biofilm creates evolving bacterial resistance
- Investigate the paradigm shift in current literature for biofilm management
- Explain the mechanisms of biofilm response to debridement and regrowth

Findings and Implications

An expert panel of five wound care certified or certification eligible nurses who care for patients with nonhealing wounds reviewed and evaluated the educational module using a 5-point Likert scale questionnaire (see Appendix B). The panel was asked for anonymous feedback to assess the feasibility of the learning objectives for the biofilm education module and identified that the expert panel had a diverse awareness of biofilm and the impact biofilm has on wounds (Table 1).

Table 1

Expert Panel Experience Results for the Staff Education Module: Baseline Information

Baseline questions	Scaled responses		
	Very familiar	Moderately familiar	Not very familiar

Question 1: Are you familiar with the term "biofilm"?	4	0	1
	Yes, previous education	Biofilm product in-service	No
Question 2: Have you received any continuing education regarding biofilm in the past five years?	3	1	1
	Very comfortable	Moderately comfortable	Not very comfortable
Question 3: You are comfortable assessing and treating biofilm?	3	1	1

Panel members experience in wound care and biofilm varied from one that was new to wound care to the very experienced. The most novice panel member expressed that the slide background texture was a little distracting but otherwise agreeing with the remaining panel either selecting *agree* or *strongly agree* to the survey questions, the background of the core slides was adjusted lighter (see Table 2).

Table 2

Expert Panel Module Evaluation Results for Staff Education Module Objectives

Statement	Score	Total	Mean	Percentage
1. The education module is clear and easy to follow	5, 5, 5, 5, 4	24	4.8	96
2. The education module is relevant to my nursing practice	5, 5, 5, 4, 4	23	4.6	92
3. The education module explains the difference between bacteria in a biofilm and planktonic bacteria.	5, 5, 5, 4, 4	23	4.6	92
4. The education module presents the biofilm lifecycle clearly and in order of occurrence.	5, 5, 5, 5, 5	25	5.0	100
5. The education module examines the role of biofilm in different aspects of health care.	5, 5, 5, 5, 4	24	4.8	96
6. The module explains how biofilm protects bacteria.	5, 5, 5, 5, 4	24	4.8	96

7. The education describes how biofilm supports evolving bacterial resistance	5, 5, 5, 4, 4	23	4.6	92
8. The education module investigates the paradigm shift in current literature for biofilm management	5, 5, 5, 5, 4	24	4.8	96
9. The education module explains the mechanisms of biofilm response to debridement and regrowth.	5, 5, 5, 5, 4	24	4.8	96
10. The educational module content is relevant and appropriate to current nursing practice.	5, 5, 5, 5, 5	25	5.0	100
11. Nurses will be able to complete the educational module as an aspect of clinical orientation	5, 5, 5, 5, 5	25	5.0	100
12. The educational module will increase nursing knowledge of biofilm.	5, 5, 5, 5, 5	25	5.0	100
13. The educational module will help to identify areas where nurses have gaps in knowledge and need remediation.	5, 5, 5, 5, 5	25	5.0	100
14. The material covered in the module reviews the role of nurses in recognizing and treating biofilm.	5, 5, 5, 5, 5	25	5.0	100
15. The length of time to complete the module is appropriate	5, 5, 5, 5, 5	25	5.0	100
16. Overall, I am satisfied with the content and quality of the Biofilm Education module	5, 5, 5, 5, 5	25	5.0	100

Note. Scoring Key: 5= Strongly Agree, 4= Agree, 3= Neither or N/A, 2 = Disagree, 1= Strongly Disagree. Questions 1-16 are of equal weight on 5-point Likert scale

All participants (which included the nurse CEO) indicated that the education module was very informative and easy to understand. The full use benefit of this module will be to orient nurses to baseline biofilm knowledge and then to periodically use the module to facilitate closing-the-loop in the QI process for the organization. As a method to enable performance improvement, the organization's key stakeholders also now recognize that more advanced testing using confocal microscopy may be needed for a subset of patients which will necessitate making a higher level of testing available. The increased understanding of the critical role biofilm plays in wound healing has been invaluable.

It was important to understand methods to facilitate adult learning and the needs of the certified nurse, integrating these approaches into this project. Over time as nurses gain meaningful experience assessing and treating patients with biofilm-based infections, the translation of new research and an understanding of how to evaluate new products, and procedures will become easier elevating patient care that has a tangible, measurable impact.

Limitations/Potential Impact of Findings

Many of the articles reviewed had suggestions about biofilm assessment and treatment directed more at physicians which included biopsies and inpatient debridement. Three articles specifically discussed the role of nurses in the care of wounds with high bioburden and biofilm (Brown, 2018; Gardner, 2009; Hurlow, 2016). Much of the research yielded randomized controlled trials (RCTs) over the last ten years; however, only two RCTs provided information about how patients responded to the care or treatments selected (Kim, 2018 Wolcott, 2015). One of the foremost findings of the project is that the confusion surrounding the treatment and eradication of biofilm remains confusing, often incomplete, and siloed among groups. While information about the existence of biofilm is robust, there is clear evidence that optimal biofilm care requires ways to treat the structure leaving many other recommendations limited in their usefulness, much of the research was already out-of-date.

Technology in this field is changing rapidly and will require the module to be updated frequently as research emerges. Whereas information abounds, searching key words such as ‘biofilm or structure’ should be a more direct method for future updates.

The education module will be beneficial since the module represents the most up-to-date information available. Additionally, findings from the project has components that can be generalized to the whole of nursing but will be most useful to organizations who contend with infections that are biofilm-based. One consideration of the project is the length of the Biofilm Module. With 58 slides, it will require about 2 hours of scheduled orientation time for module review, questions, and answers. At final review, the CEO believed that considering the topic, the length of the education module was appropriate for orientation with segments for remediation/review as needed.

Implications for Social Change

The DNP project has the potential to impact many organizations and staff nurses who are like the host organization or those wishing to improve nursing knowledge of biofilm, improve patient safety, and reduce the rate of infections without dependence on wound cultures alone. Implications for positive social change include more efficient patient care, a better understanding of the inflammatory process where infections and biofilm begin, wound healing trajectories in line with published standards, improved organizational relations with contracted facilities which makes high-quality wound care available among communities of rural and underserved populations.

Recommendations

Research advocates that upstream interventions addressing infection and pathogenic loads in chronic wounds reduces cost and improves wound healing and patient care (Fife, 2012). Currently, the project site is experiencing higher than anticipated infections among established patient whose wounds previously tested negative for

pathogens. After a recent QI project, it was believed by organizational leadership that nurses may not be receiving appropriate orientation or have had current education on assessing the subclinical signs of infection in patient wounds instead relying on wound culture results which may misinform the status of the wound. I have recommended that the Biofilm education module is implemented at each new clinical staff orientation as well as implemented for current clinical staff in a method that fits current clinical schedules. The education module that has been reviewed and validated by a panel of experts will serve as the definitive source for wound infection assessment and be implemented as needed based on further QI evaluations. Continued effort to pair experienced nurses who understand the concepts of biofilm with more novice nurses who have had less exposure to the concepts of biofilm and infection should be considered.

Plans to extend this DNP project beyond this phase of the DNP project may include a quiz, room posters to serve as reminders of nurse biofilm assessment steps, with a possible presentation to other departments at partnering facilities in collaboration with the project site team. One of the members of the expert panel has asked to use the education for their wound care staff and Medical Director as well. I foresee implementation of this education within the next 3 - 6 months due to the critical nature of the topic.

Strengths and Limitations of the Project

This project has provided an excellent forum to educate the expert panel on the nuances of biofilm and the insidious nature of biofilm. Based on the feedback from the panel, members increased awareness of how to evaluate new products and how to advise

partner sites on product selection. A strength of the project is the timeliness of the research, some as recent as the last 18 months, and the immediate benefit of new knowledge that can be implemented without significant interference with clinic flow. Since the organization has no current biofilm education, introducing new research and knowledge into the clinical equation is expected to have a positive and lasting impact on patient care. Additionally, the organization has come to realize the importance of current and ongoing education, regardless of staff having certification or eligible for certification. For specialty wound care nurses, detailed information such as in the Biofilm education module provides the next level of expertise needed to care for patients with wounds.

At this point, the organization and site team are brain-storming about how to dig deeper into other subjects critical to patient wound healing; including more in-depth education regarding ischemia, managing nutrition, edema management and off-loading that is patient-oriented not based on clinical convenience. Further research is needed in these topics but represents the compounded effect awareness of research has. Additionally, the organization wants to add to each formalized educational activity an economic component that demonstrates for the whole staff the impact of good care on the business aspects of reimbursement and wound healing.

Section 5: Dissemination Plan

This project addressed a gap in nursing knowledge through a biofilm staff education module to inform wound care nurses about wound assessment and treatment for biofilm. Results of the evaluation have been presented to the organizational leadership team consisting of the CEO, the nurse educator, and the director of clinical services. The entire program will be discussed and presented at the next quarterly board meeting by the leadership team. The plan to disseminate a newly developed PowerPoint of the biofilm education module will begin with the next clinical staff orientation for newly hired nurses and for immediate implementation for current staff. The results of the evaluation by the project team were discussed with new strategies for education and suggestions for topics directed at improving clinical outcomes. The primary audience for this DNP project is certified or certification eligible staff nurses; however, the leadership team has decided to implement the education module for all clinical employees during the orientation process, with expanded or modified segments offered to partner sites for areas such as housekeeping, operating room, ambulatory surgery, and the emergency department. Information in the education module will be useful as a guideline for patient wound assessment and can assist nurses in providing patient-centric care.

Analysis of Self

I started my DNP program in early 2014. Initially, I was encouraged to a different doctoral program rooted in research; however, my passion has always been clinical. Choosing a practice doctorate was a natural extension of my Clinical Nurse Specialist degree that I achieved in 2012. As I learned in my Clinical Nurse Specialist program,

clinical practice has many spheres and can influence a broad range of applications to health care. I found that translating research into practice and helping other clinical providers understand how research is practical in everyday care appealed to me. As a nurse specialized in wound care for nearly 20 years, even I did not realize the full impact of biofilms and the infections they generate until recent personal experience. I then became an avid researcher, understanding that I needed more tools to apply research-based education. As a doctoral student and graduate, I hope to impact health care focused on knowledge development that is rooted in practice. As a terminal degree for my nursing career, this DNP will help to bridge the gap between theory and practice and allow me to mentor others in taking research to the bedside accurately and appropriately.

Being a nurse has given me many opportunities; beginning in critical care and the emergency department, I have been a nurse case manager, in nursing education, QI, and wound care. Each one of these roles helped me mature and see health care from differing perspectives, developing my ability to think creatively and critically and make a difference in the lives of those around me. My goals for this DNP program have been to finish, allowing me to step into a different level of credibility and professionalism. The program has involved my family sacrificing, but it has been stimulating and challenging. I have learned perseverance, and I believe that the complexity of clinical care demands transformative nursing leadership—leadership that works side by side with those who make a difference in people's everyday lives. During this journey, my professors and mentors have imparted their knowledge in a way that inspired me to realize that learning really is a life-long commitment. As a graduate of this program, my goal is to continue to

pass on what I have learned and will learn and be a champion of translating research into bedside practice for nursing and health care in general.

Summary

Paradigm change is not easy or quick, but when evidence presents irrefutable conclusions, change is required. The discovery that biofilm is strengthened by its structure is changing practice. For over five decades science has known of biofilm but as with all areas of research, revelation is progressive. Because of innovators and researchers, it is clear why there is antibiotic resistance, ear and sinus infections keep recurring, high doses of intravenous antibiotics fail to save patients, and why it is important to eradicate biofilm in its earliest stages. In the context of this DNP project, a biofilm staff education module was developed for nurses specialized in wound care, either certified or certification eligible, to bridge the gap between emerging research and the assessment and care of patients with chronic nonhealing wounds. A panel of five experts evaluated the module and provided feedback on the staff education module. Information for the module content was gathered from many sources aiming to include the most recent as well as established research to inform wound nurse practice and professionalism. I followed the Walden University staff education project manual as a guide to successfully plan and evaluate this module and project.

This education module will improve nurse assessment and treatment of patients who have chronic nonhealing wounds and reduce the impact of infection on patient outcomes. Additionally, through having a clear understanding of what biofilm is, how it forms, and why biofilm is resilient, nurses who care for all types of patients with

recurring infection or at risk for progressing infection will be more prepared to advocate for early intervention and definitive biofilm eradication.

References

American Board of Wound Management. (2014). *Recertification handbook*. Retrieved from http://www.abwmcertified.org/uploads/pdfs_general/Recertification_Handbook_revised_January_2014.pdf

American Association of Colleges of Nursing. (2006). *The essentials of doctoral education for advanced nursing practice.* Retrieved from http://www.aacn.nche.edu/publications/position/DNPEssentials.pdf

American Nurses Credentialing Center. (2014, September). *The importance of evaluating the impact of continuing nursing education on outcomes: Professional nursing practice and patient care.* Retrieved from http://www.nursecredentialing.org/Accreditation/ResourcesServices/Evaluatingthe-Impact-CNE-Outcomes.pdf

American Nurses Association. (2001). *Nursing scope and standards of practice*. Washington, DC: Author.

Armstrong, D. L. (1998). Validation of a diabetic wound classification system: The contribution of depth, infection, and ischemia to risk of amputation. *Diabetes Care, 21*(5), 855-859.

Attinger, C., & Wolcott, R. (2012). Clinically addressing biofilm in chronic wounds. *Advances in Wound Care, 1*(3), 127-132.

Bedell, B. B. (2003). How a wound resource team save expenses and improved outcomes. *Home Health care Nurse, 21*(6), 397-403.

Benner, P. W., & Wrubel, J. (1982a). Skilled clinical knowledge: The value of perceptual awareness, Part 1. *Journal of Nursing Administration, 12*(5), 11-14. doi:10.1097/00005110-198205000-00003

Benner, P. W., Wrubel, J. (1982b). Skilled clinical knowledge: The value of perceptual awareness, Part 2. *Journal of Nursing Administration, 12*(6), 28-33. doi:10.1097/00005110-198206000-00008

Brixley, J. (2005). *Interruptions in workflow for RNs in a level one trauma center.* Retrieved from http://psqh.com/distractions-and-interruptions-impact-onnursing/print

Brown, A. (2018). Diagnosing and managing infection in acute and chronic wounds. *Nursing Times (online), 114*(7), 36-41.

Burger, J. L., Parker, K., Cason, L., Hauck, S., Kaetzel, D., O'Nan, C., & White, A. (2010). Responses to work complexity: The novice to expert effect. *Western Journal of Nursing Research, 32*(4), 497-510.

Cary, A. (2001). Certified registered nurses: results of the study of the certified workforce. *The American Journal of Nursing, 101*(1), 44-52. Retrieved from http://www.jstor.org/stable/3522294

Chadha, T. (2014) Bacterial biofilms: Survival mechanisms and antibiotic resistance. *Journal of Bacteriology Parasitology, 5*(3), 186 - 190. doi:10.4172/2155-9597.1000190

Corbett, L. (2012). Wound care nursing: Professional issues and opportunities. *Advances in Wound Care, 1*(5), 189-193.

Costerton, J. S. (1999). Bacterial biofilms: A common cause of persistent infections. *Microbes, Immunity, and Disease, 284,* 1318-1322. doi:10.1126/science.284.5418.1318

Di Domenico, E. G., Farulla, I., Prignano, G., Gallo, M. T., Vespaziani, M., Cavallo, I., . . . Ensoli, F. (2017). Biofilm is a major virulence determinant in bacterial colonization of chronic skin ulcers independently from the multidrug resistant phenotype. *International Journal of Molecular Sciences, 18*(5), 1077. doi:10.3390/ijms18051077

Edmiston, C. M. (2016). A narrative review of microbial biofilm in post-operative surgical site infections: Clinical presentation and treatment. *JWC Journal of Wound Care 25*(12), 693-702. doi:10.12968/jowc.2016.25.12.693

Field, B. B. (2014). Using the knowledge to action framework in practice: A citation analysis and systematic review. *Implementation Science, 9*(172), 14. doi:10.1186/s13012-014-0172-2

Fife, C. (2012). Wound care outcomes and associated cost among patient treated in U.S. outpatient wound centers: Data from the U.S. wound registry. *Wounds, 24*(1), 10-17. Retrieved from http://www.uswoundregistry.com/Specifications/VLU002.pdf

Ford, S. (2012, August 31). Senior nurses 'resistant' to evidence-based practice. *Nursing Times*. Retrieved from https://nursingtimes.net

Fullam, C. (1998). The triad of empowerment: Leadership, environment, and professional traits. *Nursing Economics, 16*(5), 254-257.

Gardner, S. H. (2009). Clinical signs of infection in diabetic foot ulcers with high microbial load. *Biological Research for Nursing, 11*(2), 119-128.

Graham, I. D., Logan, J., Harrison, M. B., Straus, S. E., Tetroe, J., Caswell, W., & Robinson, N. (2006). Lost in knowledge translation: Time for a map? *Journal of Continuing Education in the Health Professions, 26*(1), 13-24.

Green, L. S. (2005). Translation of research into practice: Why we can't "just do it." *Journal of the American Board of Family Practice, 18*, 541-545.

Hales, B. T. (2008). Development of medical checklists for improved quality of patient care. *International Journal Quality Health Care, 20*, 22-30.

Han, G. C. (2017). Chronic wound healing: A review of current management and treatments. *Advances in Therapy, 34*(3), 599-610. doi:10.1007/s12325-017-0478y

Health Research & Educational Trust. (2013). *Checklists to improve patient safety.* Retrieved from http://www.hpoe.org/Reports-HPOE/CkLists_PatientSafety.pdf

Hurlow, J. (2016). Understanding biofilm: What a community nurse should know. *British Journal of Community Nursing, 21*(s9), S26-S33.

Institute of Medicine. (2000). *To err is human: Building a safer health system.* Washington, DC: National Academy Press.

Institute of Medicine. (2001). *Crossing the quality chasm: A new health system for the 21st century.* doi:10.17226/10027.

Institute of Medicine. (2011a). *Clinical practice guidelines we can trust.* Washington, DC: The National Academies of Sciences, Engineering, Medicine.

Institute of Medicine. (2011b). *The future of nursing: Leading change, advancing health.* Washington, DC: National Academies Press.

Jamal, M. e. (2018). Bacterial biofilm and associated infections. *Journal of the Chinese*

Medical Association, 81(1), 7-11.

Kelley, P. W., & Whatson, T. (2013). Making long-term memories in minutes: A spaced learning pattern from memory research in education. *Frontiers in Human Neuroscience*. doi:10.3389/fnhum.2013.00589

Kim, D. N. (2018). Clinical assessment of a biofilm-disrupting agent for the management of chronic wounds compared with standard of care: A therapeutic approach. *Wounds, 30*(5). Retrieved from http://www.woundsresearch.com

Kornell, N. C. (2010). Spacing as the friend of both memory and induction in young and older adults. *Psychology and Aging, 25*(2), 498-503.

Kress, C. (2018). Practical tips for facilitating research in clinical nursing practice. *Journal of Continuing Education in Nursing, 49*(7), 294-296.

Lebeaux, D. C., Chauhan, A., Rendueles, O., & Beloin, C. (2013). From in vitro to in vivo models of bacterial biofilm-related infections. *Pathogens, 2*(2), 288-356. doi:10.3390/pathogens2020288

Levin, R. F., Fineout-Overholt, E., Mazurek Melnyk, B., Barnes, M., & Vetter, M. J. (2011). Fostering evidence-based practice to improve nurse and cost outcomes in a community health setting: A pilot test of the advancing research and clinical practice through close collaboration model. *Nursing Administration Quarterly, 35*(1), 21-33. doi:10.1097/naq.0b013e31820320ff

Lipsky, B. S. (2007). Clinical predictors of treatment failure for diabetic foot infections: Data from a prospective trial. *International Wound Journal 4*(1), 30-38.

Lozano-Platonoff, A. M.-M.-D.-R. (2015). Assessment: Cornerstone in wound management. *Journal American College Surgeons 221*(2), 611-620.

Macphee, M. S.-G. (2012). An empowerment framework for nursing leadership development: Supporting evidence. *Journal of Advanced Nursing 68*(1), 159-169.

Maddox, D. (2012). Effects of venous leg ulceration on patients' quality of life. *Nursing Standard 26*(38), 42-49.

Mager, S. (2004). *Photographic wound documentation: Consistent and accurate methods can help reduce liability.* Fort Lauderdale, FL: Mager Law Group.

Majid, S. L. (2011). Adopting evidence-based practice in clinical decision making: Nurses' perceptions, knowledge, and barriers. *Journal of Medical Library Association, JMLA 99*(3), 229-236.

Metcalf, D. B. (2013). Biofilm delays wound healing: A review of the evidence. *Burns & Trauma 1*(1), DOI: 10.4103/2321-3868.113329.

Nussbaum, S. C. (2018, January). *An economic evaluation of the impact, cost and Medicare policy implications of chronic nonhealing wounds.* Retrieved from *Value in Health 21*(1): https://doi.org/10.1016/j.jval.2017.07.007

Omar, A. W. (2017 March 7). Microbial biofilms and chronic wounds. *Microorganisms 5*(1). pii: E9.

Percival, S. (2017). Importance of biofilm formation in surgical infection. *BJS British Journal of Surgery 104*, e85 - e94.

Percival, S. V. (2015). Biofilms and wounds: An identification algorithm and potential treatment options. *Advances in Wound Care 4*(7), 389-397.

Petrova, O. S. (2012). Sticky situations: Key components that control bacterial surface attachment. *Journal of Bacteriology 194*(10) *May*, 2413-2425.

Phillips, P. W. (2010). Biofilms Made Easy. *Wounds International 1*(3), 1-6.

Schaum, K. (2017, November 8). *Special to OWM: Wound care reimbursement: Things are a-changing!* Retrieved from *OWM Ostomy Wound Management 63*(11): https://www.o-wm.com/article/wound-care-reimbursement-things-are-changing

Sheehan, P. J. (2006). Early change in wound area as a predictor of healing in diabetic foot ulcers: knowing 'when to say when'. *Plastic and Reconstructive Surgery 117*(7S), 245S-247S.

Sheehan, P. J. (2003). Percent change in wound area of diabetic foot ulcers over a 4-week period is a robust predictor of complete healing in a 12-week prospective trial. *Diabetes Care 26*(6), 1879-82.

Skrepnek GH, M. J. (2017). Health care service and outcomes among an estimated 6.7 million ambulatory care diabetic foot cases in the U.S.. *Diabetes Care Jul 40*(7), 936-942.

Smith, M. S. (2013). *The path to a continuously learning health care system.* Washington (DC): National Academies Press (US).

Snyder, R. B. (2017). Wound Biofilm: Current perspectives and strategies on biofilm disruption and treatments. *Wounds Supplement 29*(6 suppl), S1-S17.

Spranca, M. M. (1991). Omission and commission in judgement and choice. *Journal of Experimental Social Psychology 27*, 76-105.

Stevens, K. (2013, May 2013). *The impact of evidence-based practice in nursing the the next big idea.* Retrieved from *OJIN: The Online Journal of Issues in Nursing 18*(2): DOI: 10.3912/OJIN.Vol18No02Man04

Tacia, L. B. (2015, February 4). *Identifying barriers to evidence-based practice adoption:*

A focus group study. Retrieved from clinical Nursing Studies: www.sciedu.ca/cns

Thomas-Hess, C. (2011). Checklist for factors affecting wound healing. *Advances in Skin & Wound Care 24*(4), 192.

Thomas-Hess, C. (2014). Focus on clinical decision support functionality: A CMS update. *Skin & Wound Care, 27*(10), 480. doi:10.1097/01.asw.0000454578.45093.63

Tokede, O. R. (2014). The value of checklists. *Journal of American Dental Association 145(7)*, 696.

U.S. Department of health and Human Services. (2015, March 19). *Healthy People 2020*. Retrieved from Office of Disease Prevention and Health Promotion.: http://www.healthypeople.gov/2020/about/How-To-Use-HealthyPeople.gov/Frequently-Asked-Questions-%28FAQs%29

Weldon, T. (2008, August). *Physician shortages and the medically underserved*. Retrieved from Council of State Governments: http://www.csg.org/knowledgecenter/docs/TIA_PhysicianShortage_Final_screen.pdf

White, R. T. (2010). Checking it twice: An evaluation of checklists for detecting medication errors at the bedside using a chemotherapy model. *Quality & Safety in Health Care 19*(6), 562-567.

Wills, E. M. (2014). Application of Theory in Nursing Education. In M. W. McEwen, *Theoretical Basis for Nursing 4th Ed.* (pp. 479 - 496). Philadelphia: Wolters Kluwer Health Lippincott Williams & Wilkins.

Wolcott, R. R. (2010). Biofilm maturity studies indicate sharp debridement opens a time dependent therapeutic window. *Journal of Wound Care 19*(8), 320-8.

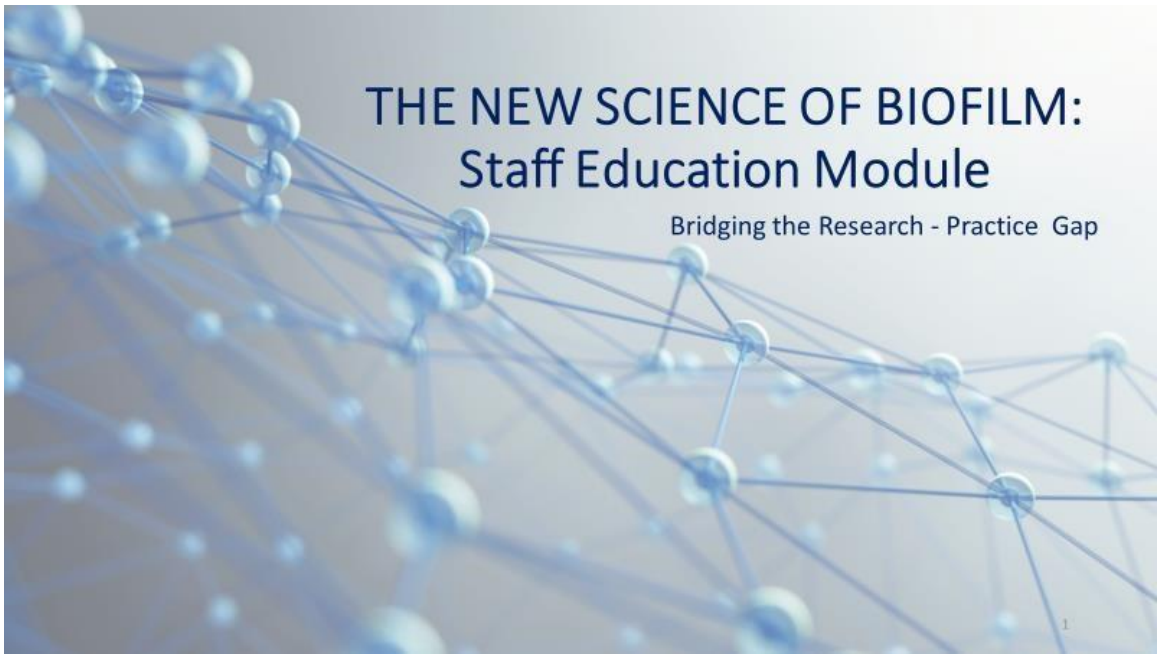
Wolcott, R. R. (2010). Chronic wounds and the medical biofilm paradigm. *Journal of Wound Care 19(2)*, 45-53.

Wolcott R. (2015). Disrupting the biofilm matrix improves wound healing outcomes. *Journal of Wound Care.24*(8):366-371.

WoundSource Editors. (2016, October 19). *8 Signs of wound infection.* Retrieved from WoundSource: https://www.woundsource.com/blog/8-signs-wound-infection

Zeller, N. (2014, April 25). *Why a zombied approach to wound center management is failing.* Retrieved from Wound Care Advantage: http://www.thewca.com/blog/201404/why-zombie-approach-wound-centermanagement-failing

Appendix A: Staff Education Module PowerPoint Presentation



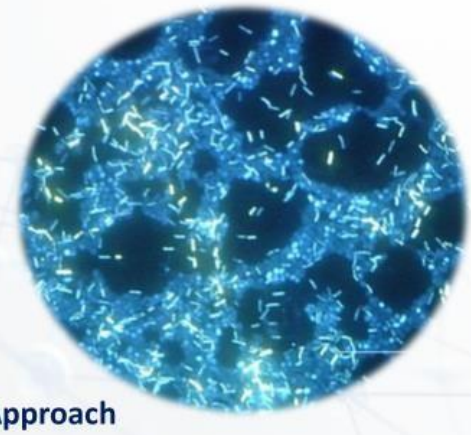
Module Objectives

1. Examining the role of nurses in biofilm treatment
2. Describing the role of biofilm in wound healing
3. Comparing biofilm bacteria from planktonic bacteria
4. Explaining the biofilm life-cycle
5. Exploring the role of biofilm in different aspects of healthcare
6. Explaining how biofilm protects bacteria
7. Describing how biofilm creates evolving bacterial resistance
8. Investigate the paradigm shift in current literature for biofilm management
9. Explain the mechanisms of biofilm response to debridement and regrowth

2

Module Overview

- The Infection Threat to Society
- Infection vs. Biofilm
- How Biofilm Begins
- Biofilm vs. Normal Wound Healing
- Biofilm Structure
- Biofilm Defense System
- Nursing Role in Biofilm Management
- Current Trends in Biofilm Treatment
- The Paradigm Shift to a Biofilm-Based Approach

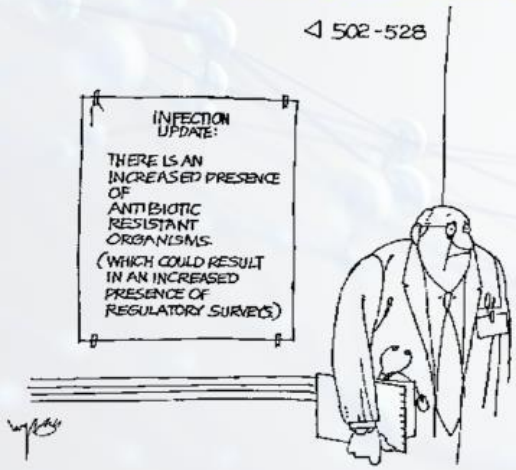


3

THE INFECTION THREAT TO SOCIETY

4

Growing Economic Threat in America



$373 Million per year due to penalties

~2 Million hospital-acquired infections with annual cost of **~$30.5 Billion**

2014

721 hospitals had their Medicare reimbursement **lowered 1%** for having high hospital-acquired infection rates

http://www.hcpro.com/HOM-46709-878/Healthcare-Humor-Infection-update.html
[CHIA] Center for Health Information and Analysis. (2015). Performance of the Massachusetts Health Care System Series: A focus on provider quality. *CHIA Center for Health Information and Analysis*, chiamass.gov.
Rau, J. (2014). Medicare cuts payments to 721 hospitals with highest rates of infections, injuries. *[KHN] Kaiser Health News*, khn.org.
Attinger, C., & Wolcott, R. (2012). Clinically Addressing Biofilm in Chronic Wounds. Advances in Wound Care, 1(3), 127–132.

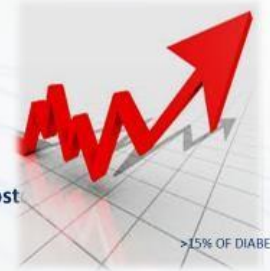
Wound Infection Threat: Economic and Societal

>6.5 M
People suffering from chronic wounds

90% CHRONIC WOUNDS AFFECTED BY BIOFILM

Annual chronic wound cost
>$30 Billion

70% WOUNDS TAKE MORE THAN 12 WEEKS TO HEAL



40% of the annual cost
~$12 Billion
is attributed to Surgical Wounds and Surgical Site Infections ranked #1 and #3 respectively

>15% OF DIABETIC FOOT ULCERS REQUIRE AMPUTATIONS

CHIA] Center for Health Information and Analysis. (2015). Performance of the Massachusetts Health Care System Series: A focus on provider quality. *CHIA Center for Health Information and Analysis*, chiamass.gov.
Rau, J. (2014). Medicare cuts payments to 721 hospitals with highest rates of infections, injuries. *[KHN] Kaiser Health News*, khn.org.
Attinger, C., & Wolcott, R. (2012). Clinically Addressing Biofilm in Chronic Wounds. Advances in Wound Care, 1(3), 127–132.

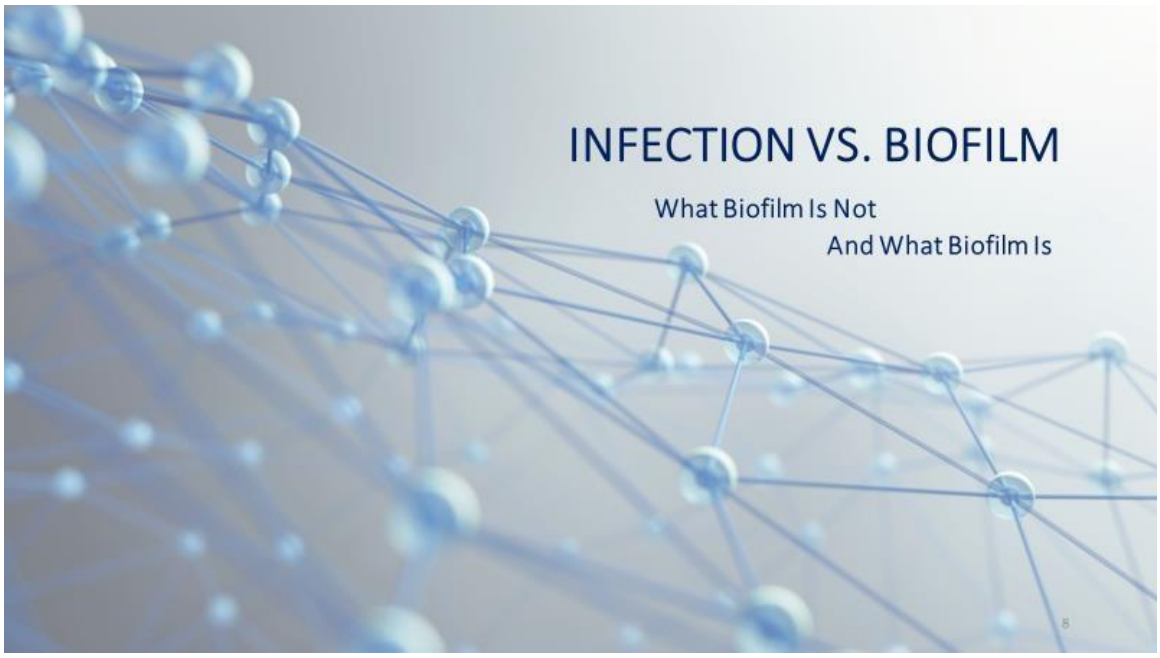
Worldwide Infection Will Be The Largest Cause Of Death By 2050

- A recent high profile report estimates that, by 2050, 10 million people will die every year due to antimicrobial resistance (AMR) unless a global response to the problem of AMR is mounted.
- Science has linked biofilms and resistant infections:
  - the defense mechanisms of biofilm may seem simple but, "acting together, these defenses help to ensure the survival of biofilm cells in the face of ***even the most aggressive antimicrobial treatment regimens"***.
- Currently according to National Institutes of Health (NIH) about ***65% of all microbial infections, and 85% of all chronic infections are associated with biofilms***.
- Biofilms form on ***wounds surfaces and medical devices*** like urinary catheters, endotracheal and tympanostomy tubes, orthopedic implants, and sutures
- Biofilm currently is proven to be in over 6% of acute wounds and over 90% of chronic wounds

Omar, A., Wright, J. B., Schultz, G., Burrell, R., & Nadworny, P. (2017). Microbial Biofilms and Chronic Wounds. Microorganisms, 5(1), 9. http://doi.org/10.3390/microorganisms5010009

Kia J. Medicare Cuts Payments to 721 Hospitals With Highest Rates of Infections, Injuries. Kaiser Health News. December 18, 2014. Available at: khn.org. Accessed August 17, 2018.

O'Neill J. Review on Antimicrobial Resistance Antimicrobial Resistance: Tackling a crisis for the health and wealth of nations. London: Review on Antimicrobial Resistance. 2014. Available from: https:// amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf



Infection Is Different Than Biofilm

The five stages of progression of infection:

- **Incubation stage**. Pathogen is actively replicating without producing symptoms.
- **Prodromal stage.** The initial appearance of symptoms, though they are usually vague.
- **Acute stage.** The maximum impact of the infectious process; there is rapid proliferation and spread of the pathogen.
- **Convalescent period**.
- **Resolution.**

FREE-FLOATING BACTERIA/PATHOGENS CAUSE INFECTION – IF LEFT UNTREATED OR UNDERTREATED CAN FORM BIOFILM

https://quizlet.com/82586496/disease-course-the-five-stages-of-progression-of-infectious-disease-flash-cards/

9

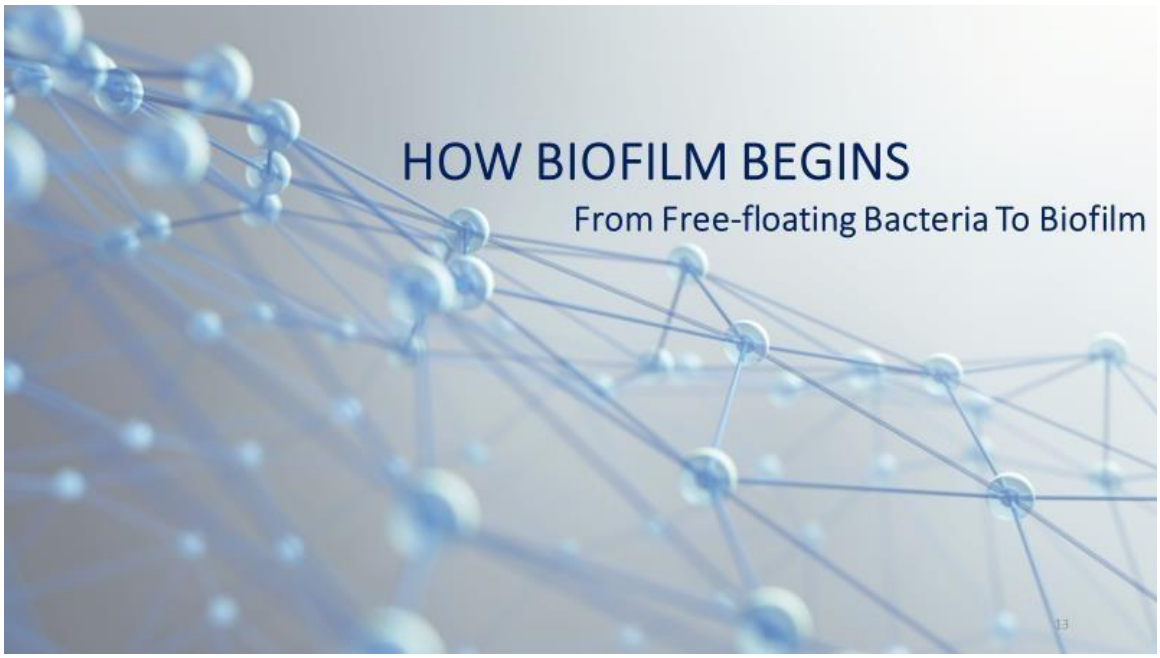
Biofilm AKA: contamination, colonization, critical colonization, bioburden

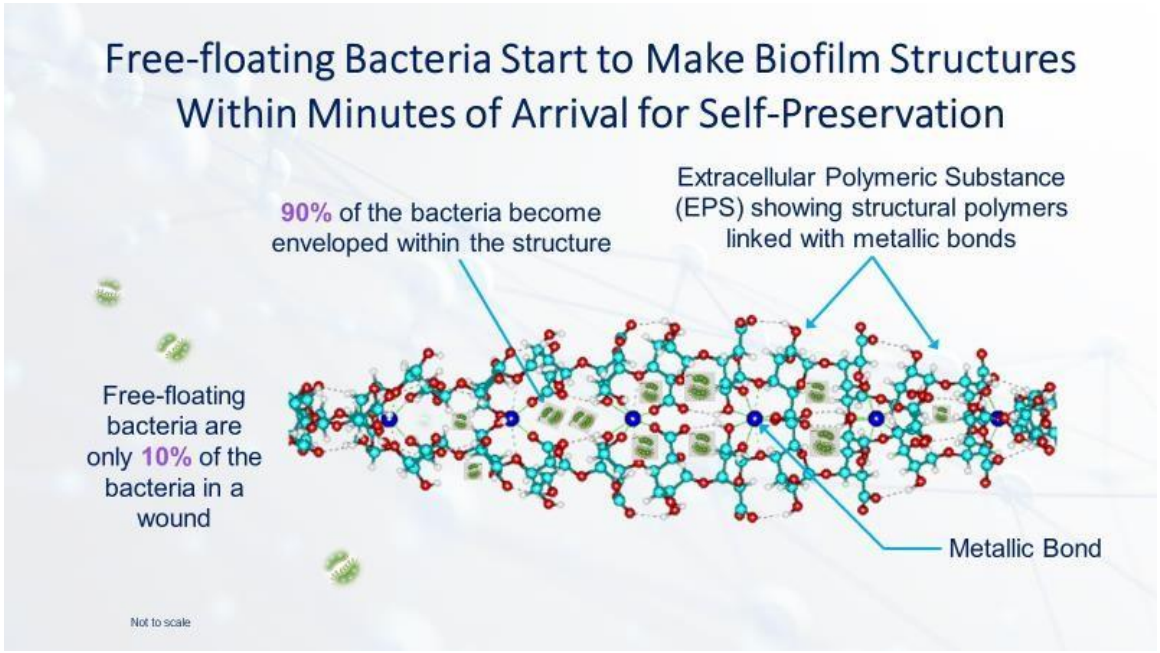
BIOFILM IS A PROGRESSIVE INFECTION

Biofilm Defined

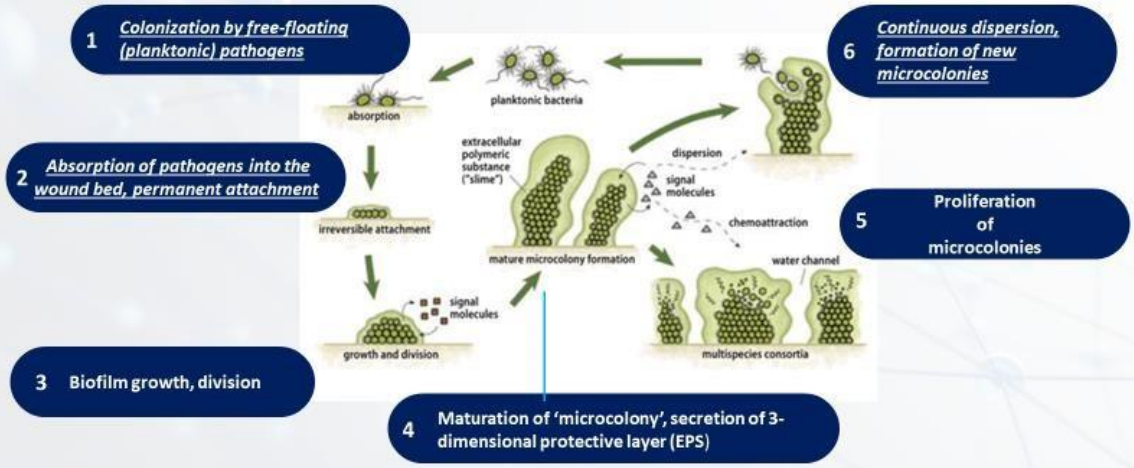
- **Biofilm –** is any group of microorganisms/pathogens (bacteria, fungi, protozoa, unicellular algae, and slime molds) that extrude a viscous polymeric substance which is used to stick to each other and adhere onto a surface (wounds, heart, lungs, ears, sinuses, suture material , implanted mesh, internal devices, and inanimate objects - such as equipment, beds, rooms, floors, and are found in nature – water).
- These adherent cells become embedded within entangled slimy exopolysaccharide strands (like a bowl of spaghetti) that is composed of extracellular ***polysaccharides, proteins, lipids, water, and DNA bonded with metallic ions.***

Phillips PL, Wolcott RD, Fletcher J, Schultz GS. Biofilms made easy. *Wounds Int J.* 2010;1(3):s1.1–s1.6


HOW BIOFILM BEGINS
From Free-floating Bacteria To Biofilm
13


Free-floating Bacteria Start to Make Biofilm Structures Within Minutes of Arrival for Self-Preservation
90% of the bacteria become enveloped within the structure
Extracellular Polymeric Substance (EPS) showing structural polymers linked with metallic bonds
Free-floating bacteria are only 10% of the bacteria in a wound
Metallic Bond
Not to scale

Biofilm Quickly Establishes a Life-Cycle



A new understanding of these microbial communities is driving a revolution that may transform the science of microbiology - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/Formation-of-a-biofilm-is-analogous-to-the-development-of-a-multicellular-organism-with_fig2_253263880 [accessed 13 Aug, 2018]

How quickly does biofilm form?

In vitro studies show

- Attach within minutes (reversible)
- Form strongly attached microcolonies in 2-4 hours (no longer reversible with typical measures
- Develop initial EPS bonds within 6-12 hours
- Become fully mature biofilms in 2-4 days
- Biofilm is able to recover rapidly from mechanical disruption (debridement) or from products that break apart the biofilm rather than dissolve the EPS, it reforms mature biofilms in 15 minutes (when bleach products are used) to 24 hours

Attinger, C., & Wolcott, R. (2012). Clinically Addressing Biofilm in Chronic Wounds. Advances in Wound Care, 1(3), 127–132.

16

How quickly do biofilms form?

In vitro studies show

- Exposing wound bacteria to sub-inhibitory antibiotic concentrations, or to the wrong antibiotics, may induce mucoid phenotypes, which generate thicker biofilms with additional matrix components
- 99.9% of all bacteria can potentially form biofilm but the most common are (***staphylococci***, streptococci, ***pseudomonas*** and Escherichia coli (look at the antibiograms from the lab for most common organisms seen at the facility)
- Biofilm become rooted into the wound bed, they are not superficial once established

Attinger, C., & Wolcott, R. (2012). Clinically Addressing Biofilm in Chronic Wounds. Advances in Wound Care, 1(3), 127–132.

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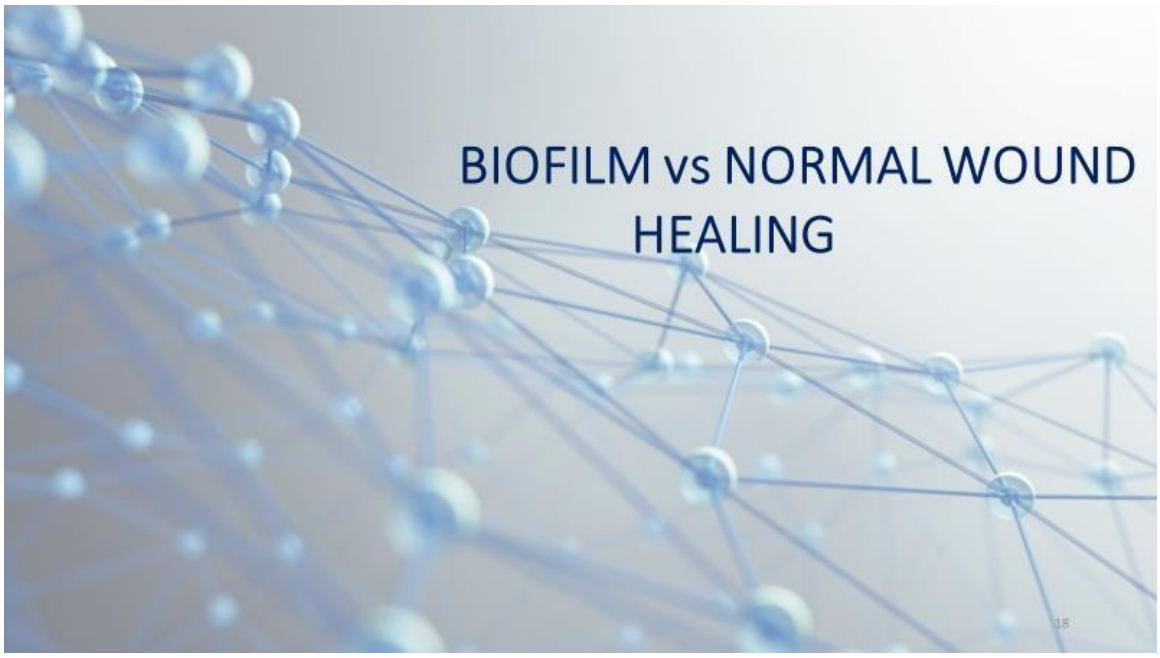
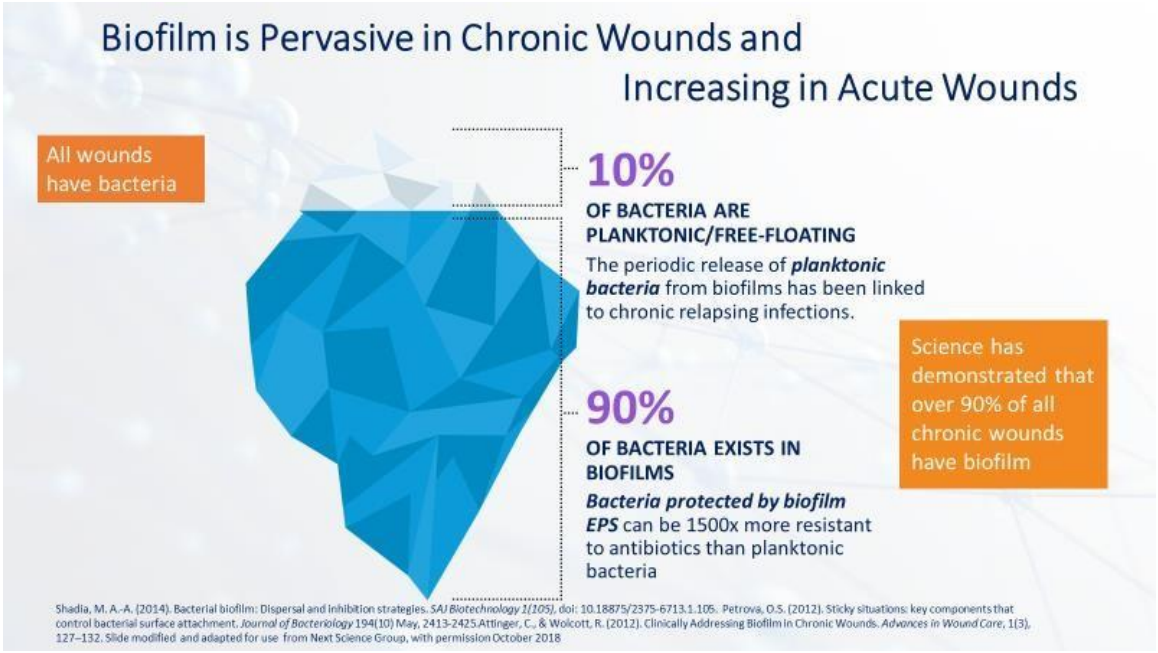
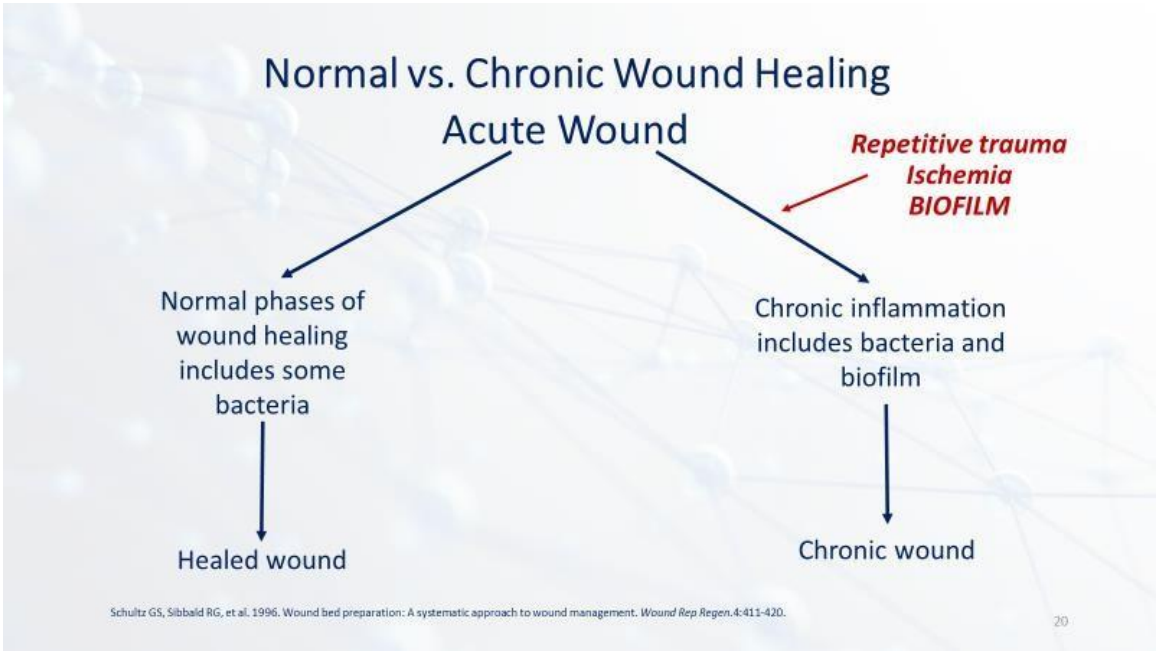



Biofilm is Pervasive in Chronic Wounds and Increasing in Acute Wounds
All wounds have bacteria
10%
OF BACTERIA ARE PLANKTONIC/FREE-FLOATING
The periodic release of planktonic bacteria from biofilms has been linked to chronic relapsing infections.
Science has demonstrated that over 90% of all chronic wounds have biofilm
90%
OF BACTERIA EXISTS IN BIOFILMS
Bacteria protected by biofilm EPS can be 1500x more resistant to antibiotics than planktonic bacteria
Shadia, M. A.-A. (2014). Bacterial biofilm: Dispersal and inhibition strategies. SAJ Biotechnology 1(105), doi: 10.18875/2375-6713.1.105. Petrova, O.S. (2012). Sticky situations: key components that control bacterial surface attachment. Journal of Bacteriology 194(10) May, 2413-2425.Attinger, C., & Wolcott, R. (2012). Clinically Addressing Biofilm in Chronic Wounds. Advances in Wound Care, 1(3), 127–132. Slide modified and adapted for use from Next Science Group, with permission October 2018


Normal vs. Chronic Wound Healing
Acute Wound
Repetitive trauma
Ischemia
BIOFILM
Normal phases of wound healing includes some bacteria
Chronic inflammation includes bacteria and biofilm
Healed wound
Chronic wound
Schultz GS, Sibbald RG, et al. 1996. Wound bed preparation: A systematic approach to wound management. Wound Rep Regen.4:411-420.
20

Normal Wound Healing Physiology

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Normal Wound Healing - Inflammation

- Critical for normal wound healing
- Growth factors released from platelets during hemostasis attract neutrophils, which release pro-inflammatory cytokines
- Neutrophils – bacterial kill and begins natural debridement
- Neutrophils recede, macrophages/fibroblasts influx
- Macrophages release further growth factors that attract other cells and lead to proliferative phase

Slide modified and adapted for use from Next Science Group, with permission October 2018

Wound Healing is Hijacked: Biofilm Mimics the Inflammatory Phase

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Presence of Biofilm Causes Prolonged Inflammation that *Sustains* the Biofilm

Prolonged inflammation causes damage to healthy tissue

2 Inflammation

3 Proliferation 4 Remodeling

- Presence of biofilm ***stimulates*** ongoing neutrophil influx and secretion of pro-inflammatory cytokines (TNF-α, IL-1β)
  - Leads to prolonged release of MMP's
    - Leads to ***degradation*** of growth factors, receptors, extracellular matrix, and ***impairs*** cell proliferation and migration
- Biofilm formation releases small molecules which ***triggers more inflammation***
- ***Increased exudate*** from inflammation incorporates into EPS and ***provides nutrition for biofilm***
- ***Calcium in the wound or from dressings*** is recruited into the biofilm to ***perpetuate*** the protective EPS matrix

Ultimately the ineffective inflammatory response prevents wound healing and makes the body susceptible to progressive and spreading biofilm-based infection

Waters, C. et al., Host Responses to Biofilm. *Prog Mol Biol Transl Sci*. 2016;142:193-239.
Phillips, P. W. (2010). Biofilms Made Easy. *Wounds International 1*(3), 1-6. Slide modified and adapted for use from Next Science Group, with permission October 2018

BIOFILM STRUCTURE

Robust bacteria inside a protective powerhouse of reinforced extracellular polymeric substance

25

What is the Extracellular Polymeric Substance and Why Does it Matter?

Extracellular

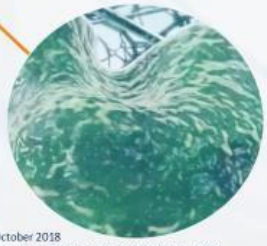
A non-cellular sticky gel secreted by bacteria to provide a physical barrier of protection while they are encased within the gel

Polymeric

Beginning as simple organic molecules; polymers inside the gel become linked with metallic bonds giving heightened strength to the structure

Substance

An insoluble capsular environment that evolves through a dialogue within itself and with the host for bacterial growth, mutation, and proliferation



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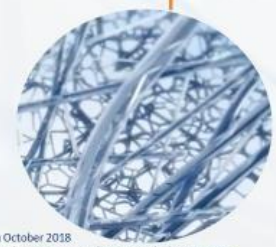

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Petrova OS. Sticky situations: key components that control bacterial surface attachment. J Bacteriol. 2010;194(10):2413–2425.

What is the Extracellular Polymeric Substance and Why Does it Matter?

Extracellular

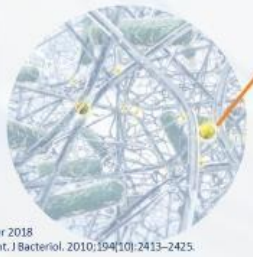
A non-cellular sticky gel secreted by bacteria to provide a physical barrier of protection while they are encased within the gel

Polymeric

Beginning as simple organic molecules; polymers inside the gel become linked with metallic bonds giving heightened strength to the structure

Substance

Once metallic bonds become established, the substance converts to an insoluble capsular environment that interacts with the host for bacterial growth, mutation, and proliferation



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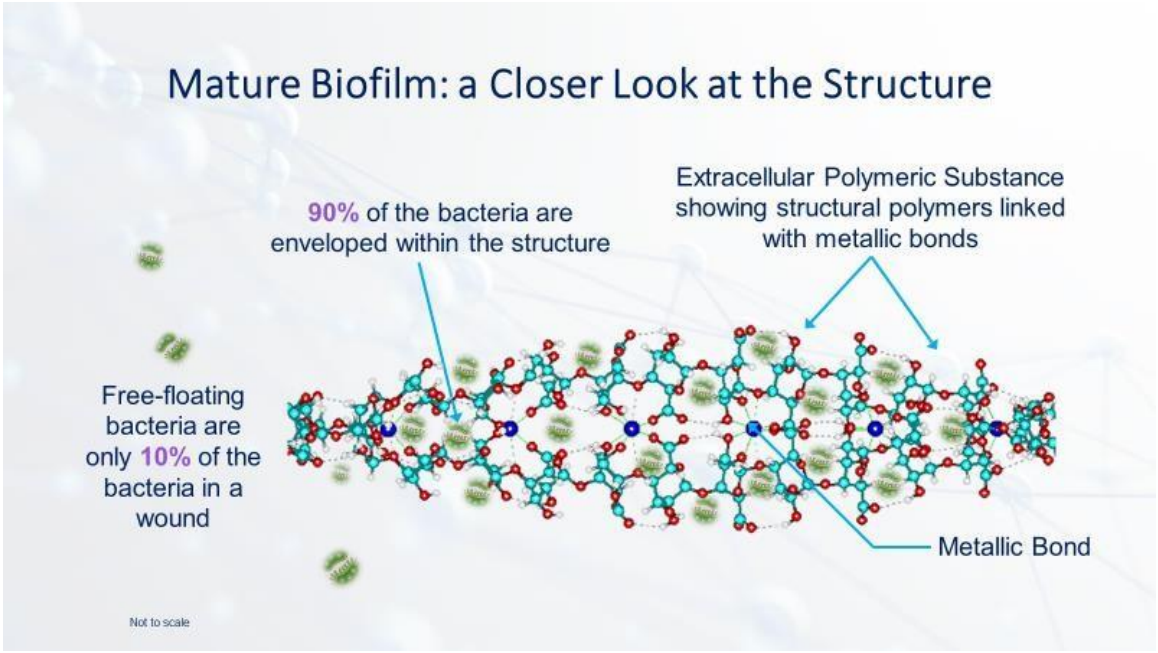
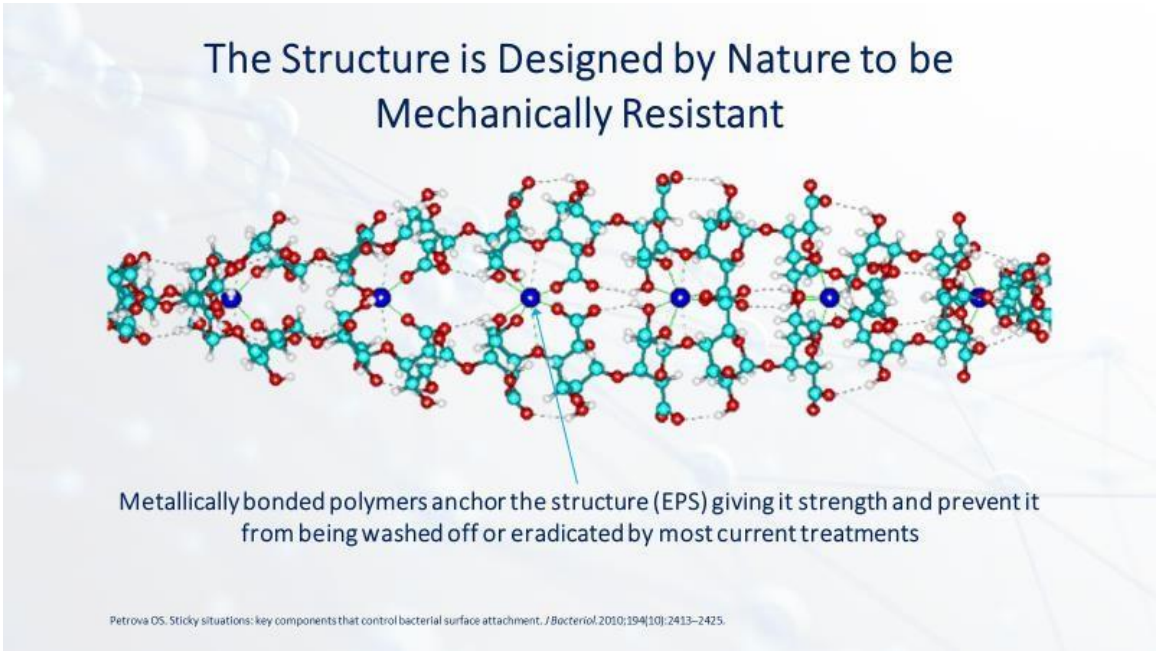

Mature Biofilm: a Closer Look at the Structure
90% of the bacteria are enveloped within the structure
Extracellular Polymeric Substance showing structural polymers linked with metallic bonds
Free-floating bacteria are only 10% of the bacteria in a wound
Metallic Bond
Not to scale


The Structure is Designed by Nature to be Mechanically Resistant
Metallically bonded polymers anchor the structure (EPS) giving it strength and prevent it from being washed off or eradicated by most current treatments
Petrova OS. Sticky situations: key components that control bacterial surface attachment. J Bacteriol. 2010;194(10):2413–2425.

Biofilm Is Precursor To Recalcitrant Infection

Pathogenic Biofilm Defenses

Extracellular polymeric substances (EPS) or Biofilm Matrix – *First line of defense for pathogens*. Extracellular polymeric substances (EPSs) are natural sugar polymers of high molecular weight secreted by microorganisms into their environment. The EPS establishes the functional and structural integrity of biofilms, and are considered the fundamental component that determines the physiochemical properties of a biofilm.

The biofilm EPS prevents dehydration and shields the pathogens against UV light, binds and neutralizes: antimicrobials, antibiotics, bleach, and metals.

Lopez, D., Vlamakis, H., Kolter, R. 2010. "Biofilms." *cold Spring Harbor Laboratory Press 2*. January 20. Accessed October 14, 2018. http://cshperspectives.cshlp.org/ .

Pathogenic Biofilm Defenses cont.

Quorum Sensing – promotes antibacterial resistance

- Cell-to-cell communication used by microorganisms within the biofilm (EPS matrix)
- Bacteria can sense when other bacteria are close and join to increase strength.
- Bacteria communicate with one another using chemical signaling molecules, a clinical vocabulary.
- As in higher organisms, the information supplied by these molecules is critical for synchronizing the activities of large groups of cells.
- Once the bacteria sense there are a large enough colony, they disperse to form new colonies and reestablish themselves and start their life-cycle over.

Blocking – the infiltration of products within the biofilm

- Host immune response and antimicrobials activity is blocked, especially those with large active molecules, small molecule antibiotics, antibodies and immune cells including Vit. D receptor sites

Quiescent or Hibernation - hides from antibiotics/antimicrobials

- When microorganisms within the EPS have temporary biological inactivity

Lopez, D., Vlamakis, H., Kolter, R. 2010. "Biofilms." *cold Spring Harbor Laboratory Press 2*. January 20. Accessed October 14, 2018. http://cshperspectives.cshlp.org/ .

Pathogenic Biofilm Defenses cont.

Multiple Phenotypes – adapts to exposure to host defenses, antibiotics and antimicrobials

- Different bacterial species contribute to the colony within the biofilm to have multiple skills sharing antimicrobial resistance, and synthesis of nutrition/oxygen some of the bacteria are aerobic but close to the base of the biofilm many are anaerobic and spore like. Over 800 phenotypes have been isolated from a biofilm.

Persister Cells – stronger than regular pathogens

- Pathogens that do not divide but produce substances that block the targets of many antibiotics and antimicrobials/disinfectants and can make the microorganisms in a biofilm up to 1500x more resistant to antibiotics

Biofilm Size and Maturity – can mature within 24-48 hours; and regrow to maturity in 24 hours after assault

- Most biofilms are very thin — just a few cell layers thick. That's too thin to see with the naked eye. Some biofilms, however, can grow many inches thick and are obviously noticeable. You'll find these thick growths as biofilm matures. The thickness of biofilms depends on several environmental factors. Some organisms can produce large amounts of EPS and hence grow a thicker biofilm.

Lopez, D., Vlamakis, H., Kolter, R. 2010. "Biofilms." *cold Spring Harbor Laboratory Press 2*. January 20. Accessed October 14, 2018. http://cshperspectives.cshlp.org/ .

Antibiotic/Antimicrobial Resistance

Antibiotic resistance occurs when bacteria change in some way that reduces or eliminates the effectiveness of drugs, chemicals, or other agents designed to cure or prevent infections. The bacteria survive and continue to multiply **causing** more harm.

Historically, the 6 main causes of antibiotic resistance have been linked to:

- Over-prescription of antibiotics
- Patients not finishing the entire antibiotic course
- Overuse of antibiotics in livestock and fish farming
- Poor infection control in health care settings
- Poor hygiene and sanitation
- Absence of new antibiotics being discovered

Center for Disease Control (2015) Antibiotics Aren't Always the Answer http://www.cdc.gov/features/getsmart/
Attinger, C., & Wolcott, R. (2012). Clinically Addressing Biofilm in Chronic Wounds. Advances in Wound Care, 1(3), 127–132.

Antibiotic/Antimicrobial Effectiveness in the Presence of Biofilm

- Antibiotics/Antimicrobials can destroy bacteria it ***can touch***, even occasionally on the biofilm surface ***but not bacteria embedded within the biofilm***
- Even if they penetrate part of the EPS layer some of the bacteria are dormant or quiescent (having a lack of biological activity)
- Because of the lack of biological cellular activity antibiotics do not recognize the pathogen as a threat, there is nothing to disrupt
- As bacteria are released from the biofilm through debridement, or topical treatments – other phenotypes of bacteria may emerge: ***use a broad spectrum treatment without resistance most biofilm has aerobic bacteria with deeper layers of anaerobic pathogens***

Donlan RM & Costerton JW. Biofilms: survival mechanisms of clinically relevant microorganisms. Clin Microbiol Rev. 2002 Apr;15(2):167-93. Attinger, C., & Wolcott, R. (2012). Clinically Addressing Biofilm in Chronic Wounds. Advances in Wound Care, 1(3), 127–132. Clayton W. Hall, Thien-Fah Mah (2017). Molecular mechanisms of biofilm-based antibiotic resistance and tolerance in pathogenic bacteria, *FEMS Microbiology Reviews*, 41(3), 1 May 2017, Pages 276–301,

Patients Who Are Predisposed to Developing Biofilm

General conditions that impair the immune system or reduce the effectiveness of treatments

- Transplant patients or patients on immunosuppressants
- Patients on chemotherapy or who have just finished chemotherapy
- Patients who received radiation to the wound site
- Ischemia or necrosis
- Patients with poor nutrition
- Comorbid conditions that impair immune function (diabetes, lupus, rheumatoid arthritis, etc.)
- Patients who have had sub-therapeutic doses of antibiotic
- Wrong antibiotic without follow-up diagnostic testing to determine if pathogens have been eradicated.

Mahoney, K. 2017. "Infection and inflammation assessment and treatment." *Wound Care Today 4(1)* 20-27.
Hurlow, J., Couch, K., Laforet, K., Bolton, L., Metcalf, D., & Bowler, P. (2015). Clinical Biofilms: A Challenging Frontier in Wound Care. *Advances in Wound Care*, 4(5), 295–301.

The Importance of Accurate Wound Assessment

- Do not depend on wound cultures to accurately diagnose biofilm they ***only reveal the presence of free-floating pathogens, and only if they are at a critical level of growth***
- Nurses play a critical role in holistic patient care and are ***often the most consistent provider*** to see the patient especially in remote settings
- Accurate wound and patient assessment is proven to ***improve patient safety, outcomes, and experience***
- Wound assessment should ***focus on the wound as well as underlying factors*** that contribute to a non-healing wound and poor outcomes
- ***Ongoing consistent assessment*** enables the nurse to identify changes in the wound status and intervene to prevent further damage or breakdown

Mahoney, K. 2017. "Infection and inflammation assessment and treatment." *Wound Care Today 4(1)* 20-27
Hurlow, J., Couch, K., Laforet, K., Bolton, L., Metcalf, D., & Bowler, P. (2015). Clinical Biofilms: A Challenging Frontier in Wound Care. *Advances in Wound Care*, 4(5), 295–301.
Attinger, C., & Wolcott, R. (2012). Clinically Addressing Biofilm in Chronic Wounds. Advances in Wound Care, 1(3), 127–132.

The Importance of Accurate Wound Assessment

There is a direct correlation between nurses using evidence-based medicine and patient outcomes (American Nurses Credentialing Center (ANCC), 2014).

- The development of biofilm precedes wound infection and requires ***timely, and early intervention and management***
- Biofilm is one of the most challenging complication of a non-healing wound and is often ***misdiagnosed as evolving inflammation***
- ***Undetected and undertreated, biofilm escalates the cost of care*** often leading to failed therapies such as negative pressure, tissue, and dressings that are ineffective
- For the patient, a ***non-healing wound impacts the quality of life and in some cases lead to sepsis, amputation, or death***

Mahoney, K. 2017. "Infection and inflammation assessment and treatment." *Wound Care Today 4(1)* 20-27
Hurlow, J., Couch, K., Laforet, K., Bolton, L., Metcalf, D., & Bowler, P. (2015). Clinical Biofilms: A Challenging Frontier in Wound Care. *Advances in Wound Care*, 4(5), 295–301.
Attinger, C., & Wolcott, R. (2012). Clinically Addressing Biofilm in Chronic Wounds. Advances in Wound Care, 1(3), 127–132.

How to Assess for Biofilm in Wounds

Assessing for biofilm begins with an awareness of the wound healing and inflammatory process and are difficult to diagnose since there are often no overt clinical signs of infection

Suspect biofilm when:

- **Tissue in a wound**
- is **friable**, (hyper granulation, which is also known as over granulation, exuberant **granulation tissue** or proud flesh)
  - **bleeds easily** on contact,
  - has developed a **strong odor or increasing pain** where there was no pain or odor
  - **fails to progress** according to established trajectories – generally, healed 50% within 4 weeks of establishing care
  - Exudate increases or changes color, consistency, amount

Mahoney, K. 2017. "Infection and inflammation assessment and treatment." *Wound Care Today 4(1)* 20-27
Hurlow, J., Couch, K., Laforet, K., Bolton, L., Metcalf, D., & Bowler, P. (2015). Clinical Biofilms: A Challenging Frontier in Wound Care. *Advances in Wound Care*, *4*(5), 295–301.

How to Assess for Biofilm in Wounds

Suspect biofilm when:

- The wound has **signs and symptoms of infection that do not respond** to antibiotics or topical treatments
- Has **negative wound cultures without healing** in spite of optimal care; biofilm is NOT detected by routine wound swabbing cultures; ***only through confocal microscopy*** of wound scrapings or tissue
- **There is recurring infection after antibiotics** are finished
- **There is an "infection" that lasts more than 30 days**

Remember: Biofilm disperses and sheds pathogens frequently rendering some therapies no longer effective

Mahoney, K. 2017. "Infection and inflammation assessment and treatment." *Wound Care Today 4(1)* 20-27
Hurlow, J., Couch, K., Laforet, K., Bolton, L., Metcalf, D., & Bowler, P. (2015). Clinical Biofilms: A Challenging Frontier in Wound Care. *Advances in Wound Care*, *4*(5), 295–301.

Traditional Topical Antimicrobial/Antiseptic Therapies

- **Non-selective - can impact all wound cells, not just pathogens** (silver based, iodine based, hypochlorous based, bleach based)
- **Often cytotoxic at effective strengths** (bleach based, iodine based)
- **Not designed for use in all wound healing phases or for all wound sizes** (for prolonged use or large wounds, iodine based – contraindicated for patients with compromised liver, on oral diabetic meds, or those pregnant or lactating)
- **Unable to penetrate into the entire biofilm EPS matrix** (silver based, polyhexamethylene biguanide hydrochloride based, bleach based, hypochlorous based products)
- **Use of antibiotics lose effectiveness as phenotypes change and can lead to resistance** (chlorhexidine based)

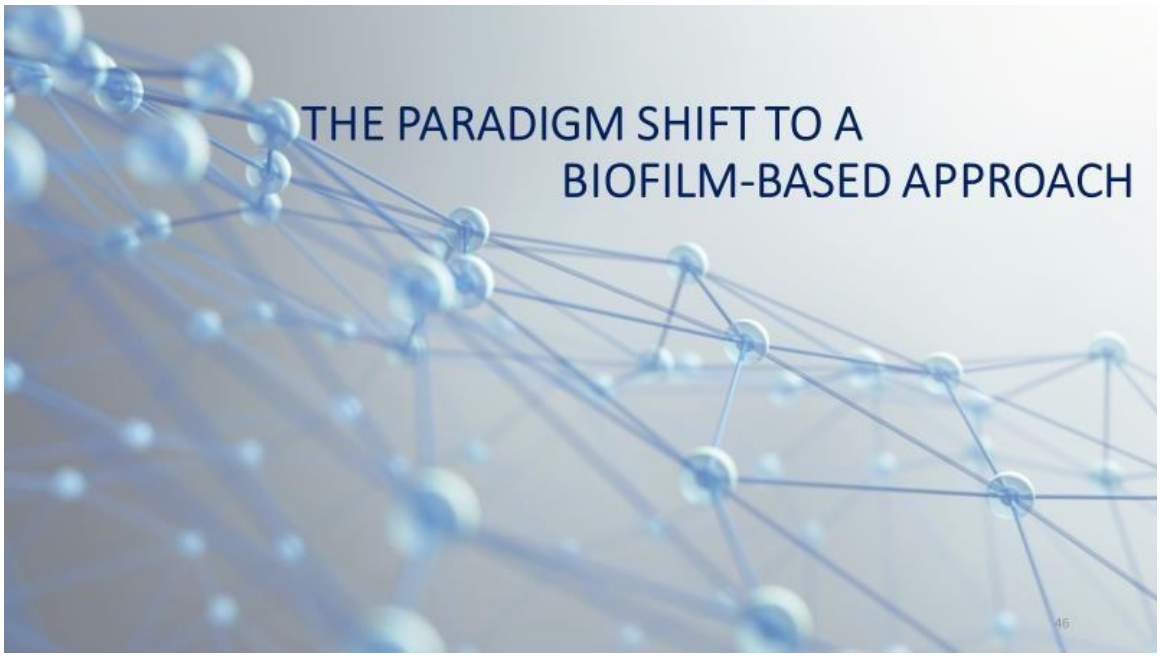
Richards JJ, et al. Controlling bacterial biofilms. *Chem Bio Chem.* 2009;10(14):2287-2294.

Existing Treatment Guidelines Target Bacteria

*Without dissolving the EPS **structure***

- **Broad antimicrobial spectrum:** Biofilm is often polymicrobial, including gram-positive and gram-negative bacteria and fungi
- **High tissue compatibility:** Does not negatively impact healthy cells or healing
- **No microbial resistance:** Has a mechanism of action that does not result in the development of microbial resistance
- **Sustained barrier effect:** Prevents biofilm re-formation in the wound

Hübner NO, Kramer A. Review on the efficacy, safety and clinical applications of polihexanide, a modern wound antiseptic. Skin Pharmacol Physiol. 2010;23(suppl):17-27
Carpenter, S. D. (2016). Expert recommendations for optimizing outcomes in the management of biofilm to promote healing of chronic wounds. *WOUNDS June*, 1- 19
Kim et al, Wounds 2018;30(5):114–119. Epub 2018 February 23



New Evidence Suggests Directly Targeting the Biofilm Structure

EXPOSE **TREAT & PREVENT**

Description	Deconstruct EPS	Current Treatment Guidelines			
	Dissolves Biofilm Structure	Broad Spectrum Antimicrobial	High Tissue Compatibility	No Microbial Resistance	Sustained Biofilm Barrier Effects
Dry dressing	NA	NA	✓	NA	X
Targeted antibiotics	No	✓	✓	Variable	X
Topical antimicrobials	No	✓	Variable	Variable	Variable
Outpatient sharp debridement	No	✓	Non-selective	✓	X
New consensus: Biofilm dissolution and microbial lysis	**Yes**	✓	✓	✓	✓

Wolcott, R. (2015). Disrupting the biofilm matrix improves wound healing outcomes. *Journal of Wound Care 24*(8), 366-71. doi: 10.12968/jowc.2015.24.8.366 Kim, P. A. (2018, February 23). *Clinic-based debridement of chronic ulcers has minimal impact on bacteria.* Retrieved from *Wounds 30*(5) 114-119: Snyder, R. B. (et al) (2017). Wound Biofilm: current perspectives and strategies on biofilm disruption and treatments. *Wounds Supplement 29(6 suppl)* , S1-S17.

Using Current Evidence Promotes Comprehensive Care

- Standard cleansing or scrubbing does not remove biofilm
- Cannot use a regular swab culture to determine pathogens *within* a biofilm only free-floating pathogens can be identified with a swab culture
- Using antimicrobial topicals and dressings may lead to a false negative culture result; no living free-floating pathogens but pathogens within the biofilm still protected and living
- Debridement is no longer considered the Gold Standard as a standalone treatment for biofilm;
- Studies support that debridement does open a time dependent window where biofilm treatment is more successful
- Reassessment should be at least weekly if biofilm is suspected as biofilm grows and replenishes rapidly

Kim PA, Attinger CE, Bigham T, et al. Clinic-based debridement of chronic ulcers has minimal impact on bacteria. Wounds. 2018;30(5):138-143.Mahoney, K. 2017. "Infection and inflammation assessment and treatment." *Wound Care Today 4(1)* 20-27 Hurlow, J., Couch, K., Laforet, K., Bolton, L., Metcalf, D., & Bowler, P. (2015). Clinical Biofilms: A Challenging Frontier in Wound Care. *Advances in Wound Care*, *4*(5), 295–301.

Using Current Evidence Promotes Comprehensive Care

- Research has determined that fragmenting biofilm such as with debridement or products that break biofilm apart stimulate a rapid regrowth of biofilm as soon as 15 minutes for some products up to 24 hours
- **New recommendations suggest that products which focus on dissolving the biofilm structure is the most successful method of biofilm eradication**
- Only use antibiotics when there is clear clinical evidence that an infection is present
  - however immune compromised patients may need the additional immune support with nutrition, supplements, and if needed systemic antimicrobial therapy
- Reassessment should be at least weekly if biofilm is suspected as biofilm grows and replenishes rapidly

Kim PA, Attinger CE, Bigham T, et al. Clinic-based debridement of chronic ulcers has minimal impact on bacteria. Wounds. 2018;30(5):138-143.Mahoney, K. 2017. "Infection and inflammation assessment and treatment." *Wound Care Today 4(1)* 20-27 Hurlow, J., Couch, K., Laforet, K., Bolton, L., Metcalf, D., & Bowler, P. (2015). Clinical Biofilms: A Challenging Frontier in Wound Care. *Advances in Wound Care*, *4*(5), 295–301. Snyder, R. B. (2017). Wound Biofilm: current perspectives and strategies on biofilm disruption and treatments. *Wounds Supplement 29(6 suppl)* , S1-S17.

When to Treat for Biofilm

- When a ***wound is over 4 weeks*** without signs of healing
- When the wound is ***progressing and then stalls*** for no obvious reason
- When ***signs or symptoms of negative change*** in the wound:
  - New onset pain, increased drainage, changes in odor (healing wound should not have a foul odor)
- When ***microscopic analysis shows polymicrobial pathogens***
- **Treating earlier rather than waiting** returns wounds to a healing trajectory

Three Part Goal:

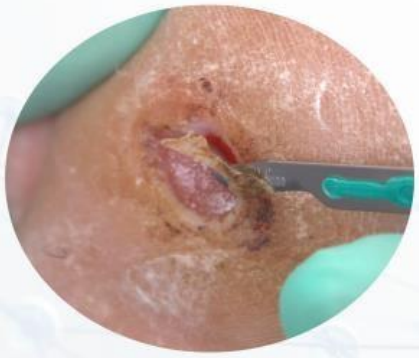
1 - Target the Structure

- Physically remove as much of the structure as possible through ultrasonic or sharp wound debridement when appropriate
- Stimulate a rapid dissolution of the structural matrix (EPS) without harming host cells
- Use technology that attaches to the biofilm's metallic bonds, allowing the matrix to dissolve into solution

ASK the Question: what is this process, product, or therapy doing to the biofilm structure?

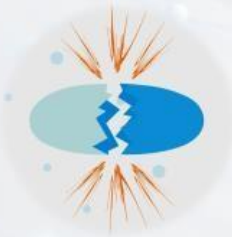
Remember: Debridement

- Outpatient debridement breaks biofilm into smaller colonies but does not entirely remove it
- Can spread the biofilm to other wound regions
- Can amplify biofilm – makes spreading more aggressive and reformation faster than on its own
- Opens a *time sensitive window* for use of an appropriate biofilm-based care



Kim PJ, et al. Clinic-based Debridement of Chronic Ulcers Has Minimal Impact of Bacteria. *Wounds.* 2018;30(5):114–119. Phillips PL, Wolcott RD, Fletcher J, Schultz GS. Biofilms Made Easy. *Wounds International.* 2010:1(3):1-6 Woo K, Keast DH, Delorme L, McKeogh E, Fournier C. Wound Care – Understanding Biofilms. Updated April 16, 2015. Accessed June 15, 2018. Wounds UK. Best Practice Statement: Making day-to-day management of biofilm simple. London: Wounds UK. Available to download from: www.wounds-uk.

Goal 2 - Target the Pathogens



- Kill free-floating (planktonic) pathogens
- Kill newly exposed pathogens protected within the EPS
- Avoid cytotoxicity to host cells

ASK the Question: does this process, product, or therapy kill pathogens that are free-floating AND within the biofilm matrix?

Goal 3 - Control the Environment

- Create physical environment that prevents attachment of planktonic organisms, biofilm reformation, and supports the wound healing process

ASK the Question: does this process, product, or therapy prevent biofilm reformation and how?

Wolcott R, et al. *Clin Microbiol Infect*. 2013;19(2):107-112. Percival SL, et al. *Adv Wound Care* (New Rochelle). 2015;4(7):389-397.

When Considering Dressings and Treatments for Biofilm

1. Identify the probable or factual presence of a biofilm
    1. Through symptoms or testing

2. Reduce the biofilm burden
    1. With debridement and with products that deconstruct biofilm AND meet the consensus guidelines of for treatment selection

3. Prevent reconstitution of the biofilm
    1. Consider products that have a long efficacy against pathogens AND that meet the recently added goal of directly targeting the biofilm structure

4. Optimize patient condition
    1. Follow guidelines for managing wounds of similar etiology: dressings for drainage, off-loading for diabetic foot ulcers, compression wraps for venous leg ulcers and edema, nutrition. **Antimicrobials do not address systemic causes for delayed healing including ischemia, and poor diabetes control.**

References:

American Nurses Credentialing Center (ANCC). (2014, September). *The importance of evaluating the impact of continuing nursing education on outcomes: Professional nursing practice and patient care*. Retrieved from ANCC American Nurses Credentialing Center:

http://www.nursecredentialing.org/Accreditation/ResourcesServices/Evaluating-the-Impact-CNE-Outcomes.pdf

Attinger, C., & Wolcott, R. (2012). Clinically Addressing Biofilm in Chronic Wounds. Advances in Wound Care, 1*(3)*, 127–132

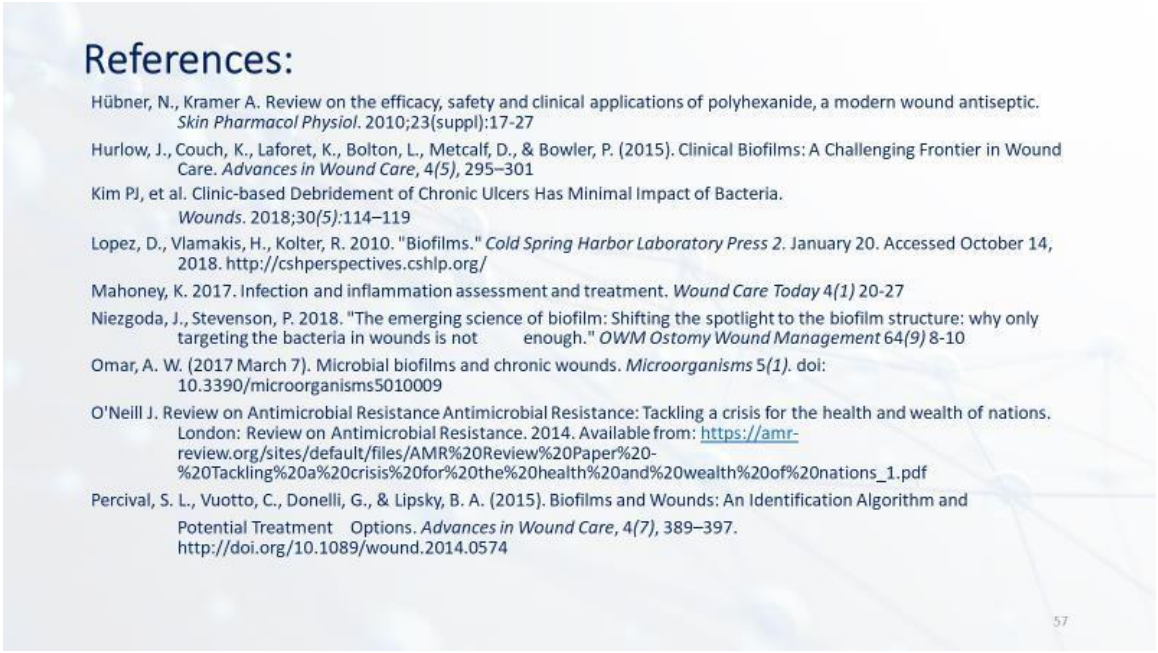
Carpenter, S. D. (2016). Expert recommendations for optimizing outcomes in the management of biofilm to promote healing of chronic wounds. *WOUNDS*. June 1-19

Center for Disease Control (2015) Antibiotics Aren't Always the Answer http://www.cdc.gov/features/getsmart/

Center for Health Information and Analysis. (CHIA). (2015). Performance of the Massachusetts Health Care System Series: A focus on provider quality. *CHIA Center for Health Information and Analysis*, chiamass.gov

Clayton W. Hall, Thien-Fah Mah (2017). Molecular mechanisms of biofilm-based antibiotic resistance and tolerance in pathogenic bacteria, *FEMS Microbiology Reviews*, 41*(3)*, 1 May 2017, Pages 276–301, https://doi.org/10.1093/femsre/fux010

Donlan RM & Costerton JW. Biofilms: survival mechanisms of clinically relevant microorganisms. *Clin Microbiol Rev*. 2002 Apr;15*(2)*:167-93



References:

Hübner, N., Kramer A. Review on the efficacy, safety and clinical applications of polyhexanide, a modern wound antiseptic. *Skin Pharmacol Physiol*. 2010;23(suppl):17-27

Hurlow, J., Couch, K., Laforet, K., Bolton, L., Metcalf, D., & Bowler, P. (2015). Clinical Biofilms: A Challenging Frontier in Wound Care. *Advances in Wound Care*, 4*(5)*, 295–301

Kim PJ, et al. Clinic-based Debridement of Chronic Ulcers Has Minimal Impact of Bacteria. *Wounds*. 2018;30*(5)*:114–119

Lopez, D., Vlamakis, H., Kolter, R. 2010. "Biofilms." *Cold Spring Harbor Laboratory Press 2*. January 20. Accessed October 14, 2018. http://cshperspectives.cshlp.org/

Mahoney, K. 2017. Infection and inflammation assessment and treatment. *Wound Care Today* 4*(1)* 20-27

Niezgoda, J., Stevenson, P. 2018. "The emerging science of biofilm: Shifting the spotlight to the biofilm structure: why only targeting the bacteria in wounds is not enough." *OWM Ostomy Wound Management* 64*(9)* 8-10

Omar, A. W. (2017 March 7). Microbial biofilms and chronic wounds. *Microorganisms* 5*(1)*. doi: 10.3390/microorganisms5010009

O'Neill J. Review on Antimicrobial Resistance Antimicrobial Resistance: Tackling a crisis for the health and wealth of nations. London: Review on Antimicrobial Resistance. 2014. Available from: https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf

Percival, S. L., Vuotto, C., Donelli, G., & Lipsky, B. A. (2015). Biofilms and Wounds: An Identification Algorithm and Potential Treatment Options. *Advances in Wound Care*, 4*(7)*, 389–397. http://doi.org/10.1089/wound.2014.0574

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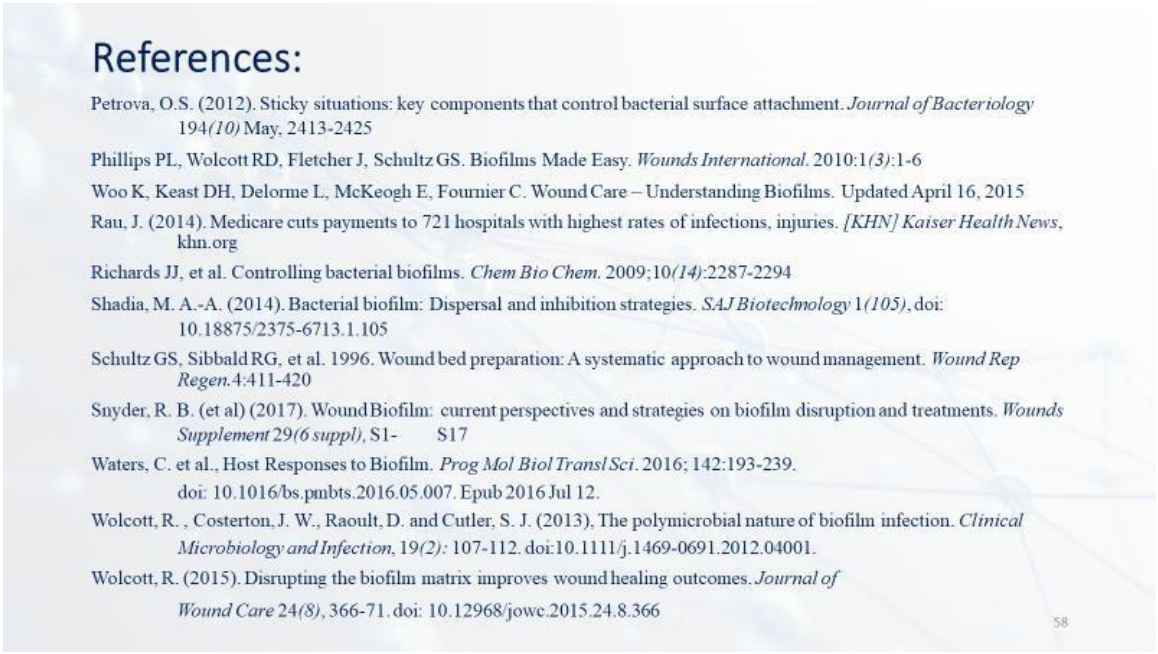

References:

Petrova, O.S. (2012). Sticky situations: key components that control bacterial surface attachment. *Journal of Bacteriology* 194*(10)* May, 2413-2425

Phillips PL, Wolcott RD, Fletcher J, Schultz GS. Biofilms Made Easy. *Wounds International*. 2010:1*(3)*:1-6

Woo K, Keast DH, Delorme L, McKeogh E, Fournier C. Wound Care – Understanding Biofilms. Updated April 16, 2015

Rau, J. (2014). Medicare cuts payments to 721 hospitals with highest rates of infections, injuries. *[KHN] Kaiser Health News*, khn.org

Richards JJ, et al. Controlling bacterial biofilms. *Chem Bio Chem*. 2009;10*(14)*:2287-2294

Shadia, M. A.-A. (2014). Bacterial biofilm: Dispersal and inhibition strategies. *SAJ Biotechnology* 1*(105)*, doi: 10.18875/2375-6713.1.105

Schultz GS, Sibbald RG, et al. 1996. Wound bed preparation: A systematic approach to wound management. *Wound Rep Regen*.4:411-420

Snyder, R. B. (et al) (2017). Wound Biofilm: current perspectives and strategies on biofilm disruption and treatments. *Wounds Supplement* 29*(6 suppl)*, S1- S17

Waters, C. et al., Host Responses to Biofilm. *Prog Mol Biol Transl Sci*. 2016; 142:193-239. doi: 10.1016/bs.pmbts.2016.05.007. Epub 2016 Jul 12.

Wolcott, R. , Costerton, J. W., Raoult, D. and Cutler, S. J. (2013), The polymicrobial nature of biofilm infection. *Clinical Microbiology and Infection*, 19*(2)*: 107-112. doi:10.1111/j.1469-0691.2012.04001.

Wolcott, R. (2015). Disrupting the biofilm matrix improves wound healing outcomes. *Journal of Wound Care* 24*(8)*, 366-71. doi: 10.12968/jowc.2015.24.8.366

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Appendix B: Project Questionnaire

The purpose of this form is to evaluate and determine the effectiveness of the Biofilm staff education module and present the results through a descriptive analysis. Please choose a four-digit number to use as a participant number.

Baseline Information:

Question 1: Are you familiar with the term “biofilm”?

5 Very Familiar	4 NA	3 Moderately Familiar (have heard of biofilm)	2 NA	1 Not Very Familiar

Question 2: Have you received any continuing education regarding biofilm in the past five years?

5 Yes Completed Specific Biofilm Training Module	4 Listened to Biofilm or Wound Infection Webinar	3 Received Inservice on Specific Biofilm Product	2 Read Article Relating to Biofilm	1 No

Question 3: You are comfortable assessing and treating biofilm?

5 Very Comfortable	4 Comfortable	3 Moderately Comfortable (have received	2 Somewhat Comfortable (have heard of biofilm)	1 Not Very Comfortable

Evaluation of Biofilm Education Module:

Statement 1: The education module is clear and easy to follow?

5 Strongly Agree	4 Agree	3 Neither Or N/A	2 Disagree	1 Strongly Disagree

Statement 2: The education module explains the role of nurses in biofilm treatment.

5 Strongly Agree	4 Agree	3 Neither Or N/A	2 Disagree	1 Strongly Disagree

Statement 3: The education module explains the difference between bacteria in a biofilm and planktonic bacteria?

5 Strongly Agree	4 Agree	3 Neither Or N/A	2 Disagree	1 Strongly Disagree

Statement 4: The education module presents the biofilm life-cycle clearly and in order of occurrence?

5 Strongly Agree	4 Agree	3 Neither Or N/A	2 Disagree	1 Strongly Disagree

Statement 5: The education module examines the role of biofilm in different aspects of health care.

5 Strongly Agree	4 Agree	3 Neither Or N/A	2 Disagree	1 Strongly Disagree

Statement 6: The module explains how biofilm protects bacteria.

5 Strongly Agree	4 Agree	3 Neither Or N/A	2 Disagree	1 Strongly Disagree

Statement 7: The education module describes how biofilm creates evolving bacterial resistance.

5 Strongly Agree	4 Agree	3 Neither Or N/A	2 Disagree	1 Strongly Disagree

Statement 8: The education module investigates the paradigm shift in current evidence for biofilm management.

5 Strongly Agree	4 Agree	3 Neither Or N/A	2 Disagree	1 Strongly Disagree

Statement 9: The education module explains the mechanisms of biofilm response to debridement and regrowth.

5 Strongly Agree	4 Agree	3 Neither Or N/A	2 Disagree	1 Strongly Disagree

Statement 10: The educational module content is adequate and appropriate to current nursing practice.

5	4	3	2	1
Strongly Agree	Agree	Neither Or N/A	Disagree	Strongly Disagree

Statement 11: Nurses will be able to complete the educational module during clinical orientation and use selected portions for refreshing or remediation?

5	4	3	2	1
Strongly Agree	Agree	Neither Or N/A	Disagree	Strongly Disagree

Statement 12: The educational module, if used for orientation and reviewed either scheduled intervals, or used for refreshing, will increase nursing knowledge of biofilm?

5	4	3	2	1
Strongly Agree	Agree	Neither Or N/A	Disagree	Strongly Disagree

Statement 13: The educational module will help to identify areas where nurses have gaps in knowledge and need remediation?

5	4	3	2	1
Strongly Agree	Agree	Neither Or N/A	Disagree	Strongly Disagree

Statement 14: The material covered in the module is appropriate?

5	4	3	2	1
Strongly Agree	Agree	Neither Or N/A	Disagree	Strongly Disagree

Statement 15: The length of time to complete the module is appropriate?

5	4	3	2	1
Strongly Agree	Agree	Neither Or N/A	Disagree	Strongly Disagree