

# A Review on the Role of Bacterial Skin Infection in the Skin

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**Abstract:** *Fungi and bacteria encounter each other in various niches of the human body, there they interact directly with one another or indirectly via the host response. In both cases, interactions can affect host health and disease. In the present review, we summarized current knowledge on fungal bacterial interaction during their commensal and pathogenic lifestyle. We focus on distinct mucosal niches. The oral cavity, lung, gut, and vagina. In addition, we describe interactions during bloodstream and wound infections and the possible consequences for the human host.*

**Keywords:** Mycobiome, microbiome, cross-kingdom interactions; polymicrobial; commensals, synergism; antagonism; mixed infections; cellulitis, erysipelas, folliculitis, skin abscess

## I. INTRODUCTION

The objective of this paper is to provide a critical review of recent literature on ‘common bacterial skin infections’ which include impetigo, folliculitis including furuncles and furunculosis, simple abscesses, erysipelas and other dermal hypodermal infections cellulitis. These are generally of mild to modest severity and can be easily treated. Rather than a systematic review, it is a personal and biased choice of those particular skin disorders. The review will include neither the field of necrotizing soft tissue infections, particularly necrotizing fasciitis, which are actually rare disorders, nor ‘diabetic foot infections, as both raise specific questions in terms of clinical presentations, diagnosis, and management.

Impetigo, the most common skin infection in children throughout the world, consists of superficial, that are mostly caused by staphylococcus aureus. Furuncles are infections of the hair follicle, frequently caused by S. aureus, in which suppuration extends to the dermis, where a small abscess develops, Furuncles differ from folliculitis in which inflammation is more superficial and pus is present within the epidermis<sup>[1]</sup>

The largest organ in your body is your skin. It has a variety of purposes, one of which is to cover and shield your body. It assists in preventing germs. However, occasionally the bacteria can result in a skin infection. This typically occurs when bacteria enter your body by a skin wound, cut, or break. Wherever the skin scrapes against one another, further skin infections may develop, particularly if the area is damp. Additionally, insufficient blood flow to a part of your body or decreased immunity from another illness or medical procedure might result in infections<sup>[2]</sup>

Erysipelas is an acute, superficial, dermal, hypodermal infection that is mainly caused by streptococci<sup>[3]</sup>. The definitive diagnosis is based on clinical findings that usually include a sharply demarcated shiny erythematous plaque of sudden onset associated with pain, swelling, and fever. Other bacterial dermal infections, often named cellulitis in the literature, are acute spreading infections of the skin, extending more deeply than erysipelas involving the subcutaneous tissues. Petechiae and ecchymoses with frequent bullae may develop in inflamed skin resulting in cellulitis<sup>[4]</sup>.

Fungi and bacteria are found on all mucosal epithelial surfaces of the human body. After their discovery in the 19<sup>th</sup> century for a long time the presence of microbes was thought to be associated mostly with disease. Only with an increased understanding of the microbial world and the increased use of antibacterial and antifungal drugs in the second half of the 20<sup>th</sup> century, people started to understand the beneficial role of microbes. Pioneer discoveries were, for instance, the production of vitamin B12 by intestinal bacteria or the protective effect of vaginal lactobacilli towards recurrent urinary tract infections<sup>[5]</sup>.

## II. LITERATURE SURVEY

1) Wibke Krüger, Sarah Vielreicher, Mario Kapitan, Ilse D. Jacobsen, and Maria Joanna Niemiec<sup>[6]</sup>

Fungi and bacteria encounter each other in various niches of the human body. There, they interact directly with one another or indirectly via the host response. In both cases, interactions can affect host health and disease. In the present review, we summarized current knowledge on fungal-bacterial interactions during their commensal and pathogenic lifestyle. We focus on distinct mucosal niches: the oral cavity, lung, gut, and vagina. In addition, we describe interactions during bloodstream and wound infections and the possible consequences for the human host.

## 2) N. Petrosillo <sup>g</sup>, M. Tumbarello <sup>h</sup>, M. Venditti <sup>a</sup>, P. Viale <sup>c</sup>, C. Viscoli <sup>l7</sup>

In 2013 the US Food and Drug Administration (FDA) issued recommendations and guidance on developing drugs for treatment of skin infection using a new definition of acute bacterial skin and skin-structure infection (ABSSSI). The new classification includes cellulitis, erysipelas, major skin abscesses and wound infection with a considerable extension of skin involvement, clearly referring to a severe subset of skin infections. The main goal of the FDA was to better identify specific infections where the advantages of a new antibiotic could be precisely estimated through quantifiable parameters, such as improvement of the lesion size and of systemic signs of infection. Before the spread and diffusion of methicillin-resistant *Staphylococcus aureus* (MRSA) in skin infections, antibiotic therapy was relatively straightforward. Using an empiric approach, a  $\beta$ -lactam was the preferred therapy and cultures from patients were rarely obtained. With the emergence of MRSA in the community setting, initial ABSSSI management has been changed and readdressed.

## 3) Richard Edlich, Kathryne L. Winters<sup>8</sup>

When considering common bacterial diseases of the skin, rather distinct clinical responses to a variety of bacterial infections have been identified. In these cases, it is the specific site of infection and the attendant inflammatory responses that provide the characteristic clinical picture. When the pyoderma extends just below the stratum corneum, it is called impetigo. Nonbullous impetigo is the most common pediatric skin infection. It usually starts in a traumatized area. The typical lesion begins as an erythematous papule, after which it becomes a unilocular vesicle. When the subcorneal vesicle becomes pustular, it ruptures and eventually becomes a yellow, golden crust that is a hallmark of the disease process. Bullous impetigo is a less common form of impetigo, accounting for fewer than 30% of all impetigo cases. It occurs in infants and is characterized by rapid progression of vesicles to the formation of bullae measuring larger than 5 mm in diameter in previously untraumatized skin.

## 4) Ilyas, Muneeb, et al. <sup>19</sup>

Though there is an abundance of information on cutaneous malignancies in transplant recipients, cutaneous infections in solid organ transplant recipients (SOTRs) are underrepresented in the dermatological literature. Our paper provides a comprehensive review of bacterial cutaneous infections within the solid organ transplant population. Cutaneous bacterial infections may lead to significant morbidity and even mortality in this immunosuppressed population. Thus, it is to the benefit of both dermatologists and other transplant care providers to better understand and recognize the features of cutaneous bacterial infections in SOTRs.

## Scope of this Review<sup>10</sup>

In this review, we summarize the current knowledge regarding fungal-bacterial interactions in health and disease, during commensalism and infection. We introduce certain fungal-bacterial combinations in the niche where they are most relevant and studied. Of note, the combinations might be of medical relevance in more than one niche. We focus on the following four major mucosal niches naturally colonized with microbes: oral cavity, lung, gut, and vagina. In addition, we address the following interactions in niches that are sterile in healthy individuals: infections of medical devices, wounds, and bloodstream. Biofilms are included in the respective chapters if implied. Microbes of high medical relevance are briefly introduced.

### Types of skin infectious diseases

#### 1. Bacterial Skin Infections;

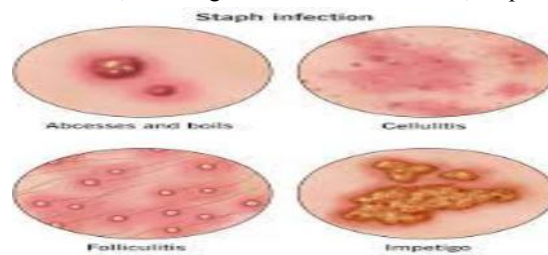
- Impetigo: Caused by *Staphylococcus aureus* or *Streptococcus pyogenes*, characterized by red sores that rupture and form a yellowish crust.

- Cellulitis: A bacterial infection affecting deeper layers of the skin, often caused by Staphylococcus or Streptococcus bacteria.
- Folliculitis: Inflammation of hair follicles caused by bacteria, typically Staphylococcus aureus.



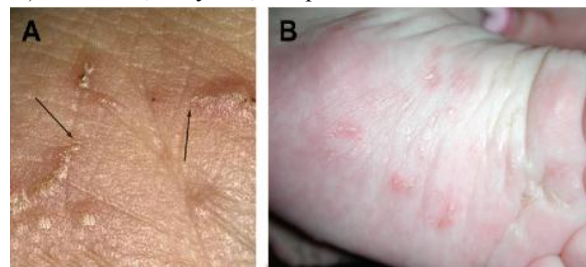
## 2. Viral Skin Infections

- Molluscum Contagiosum: Caused by a poxvirus, resulting in small, painless bumps on the skin.
- Fungal Skin Infections:
  - Ringworm (Dermatophytosis): Caused by fungi like Trichophyton or Microspores, leading to a red, circular rash.
  - Candidiasis: Caused by the yeast Candida, resulting in infections like thrush, diaper rash, or genital yeast infections.



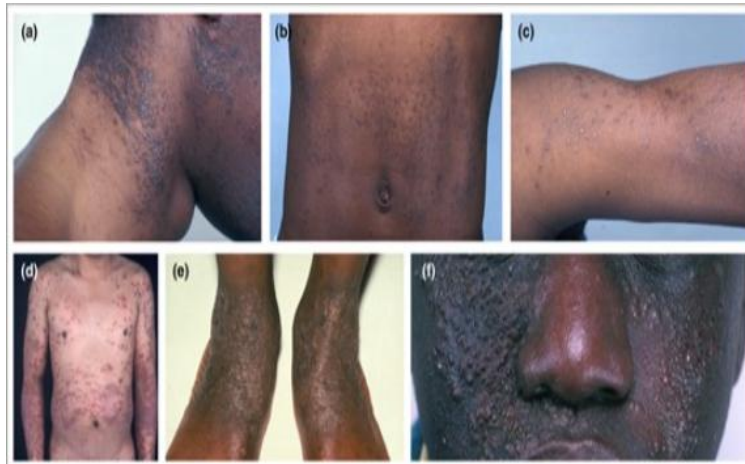
## 3. Parasitic Skin Infections;

- Scabies: Caused by the Sarcoptes scabiei mite, resulting in intense itching and a rash.
- Lice Infestations (Pediculosis): Head lice, body lice, and pubic lice infestations causing itching and irritation<sup>[11]</sup>



## Bacterial skin infection in different ethnic skin types<sup>[12]</sup>

There is wide variation in the clinical manifestation of AD in different ethnic groups. This may be a result of underlying genetic variation, which influences AD susceptibility and clinical presentation, inadequate early intervention because of masking of erythema in dark skin, and differences in both treatment response and environmental exposures. In dark-skinned individuals, perifollicular accentuation is often present and erythema appears violaceous and often muted (Fig.) This can lead to poor recognition of inflammation, underestimation of disease severity and inadequate intervention. Patients with AD of African descent often have extensor disease rather than the characteristic flexural lesions. Importantly, *S. aureus* strain differences, including variability in the presence of superantigen genes, has been shown between European American, African American and Mexican American patients with AD.



### III. EPIDEMIOLOGY AND RISK FACTORS

Infectious diseases are caused by pathogenic microorganisms, such as bacteria, viruses, parasites, or fungi. These microorganisms can be transmitted from person to person, through the air, water, food, or other vectors. Here are some common causes and factors contributing to infectious diseases:



#### 1. Microorganisms:

- Bacteria; Examples include Escherichia coli (E. coli), Streptococcus, and Staphylococcus.
- Viruses: Examples include influenza virus, human immunodeficiency virus (HIV), and the common cold viruses.
- Parasites: Examples include Plasmodium (causing malaria), Giardia, and various worms.
- Fungi: Examples include Candida (causing fungal infections) and Aspergillus.

#### 2. Transmission:

- Airborne Transmission: Respiratory droplets containing infectious agents can be inhaled by others. Examples include tuberculosis and influenza.
- Waterborne Transmission: Contaminated water sources can spread diseases such as cholera and dysentery.
- Vector-Borne Transmission: Insects or other animals can act as vectors transmitting diseases. For example, mosquitoes transmit malaria and Zika virus.

#### 3. Direct and Indirect Contact:

- Direct Contact: Physical contact with an infected person or their bodily fluids can spread diseases. Examples include sexually transmitted infections and skin-to-skin contact diseases.
- Indirect Contact: Touching surfaces or objects contaminated with infectious agents can lead to transmission. Hand hygiene is crucial to prevent diseases like norovirus.

#### 4. Poor Hygiene and Sanitation;

- Inadequate access to clean water, sanitation facilities, and poor personal hygiene can contribute to the spread of infectious diseases.

5. Immune System Factors:

- Individuals with weakened immune systems, such as those with HIV/AIDS, elderly people, or individuals undergoing immunosuppressive treatments, are more susceptible to infectious diseases.

6. Antibiotic Resistance:

- Overuse and misuse of antibiotics can lead to the development of antibiotic-resistant strains of bacteria, making infections more challenging to treat.

7. Environmental Factors:

- Environmental conditions, such as climate change, deforestation, and urbanization, can impact the distribution of vectors and the prevalence of certain infectious diseases.<sup>[13]</sup>

**IV. ORGANISMS ARE RESPONSIBLE FOR COMMON BACTERIAL SKIN INFECTIONS**

Nasal carriage of *S. aureus* was found in 50 percent of patients overall and was associated with chronic furunculosis, but not with simple furuncles 88 vs 29 percent<sup>[14]</sup>. These data strongly suggested that Pantone-valentineleucocidin is mostly associated with epidemic furunculosis and *S. aureus* nasal carriage associated with the chronicity of furuncles, as previously noticed, outbreaks of epidemic furuncles due to CA-MRSA in young, otherwise healthy people have been particularly noteworthy and in many US cities, MRSA now represents the most common pathogen isolated in the emergency department from patients with skin and soft tissue infection<sup>[15]</sup>.

In five previously healthy patients who presented with endocarditis after developing furunculosis due to CA-MRSA, blood culture isolates were found to be PVL gene positive and carried the type element, and pulse field gel electrophoresis confirmed that the skin isolates cultured from the patient's blood<sup>[16]</sup>. On the other hand, a considerable variation in the MRSA rate in the skin and subcutaneous tissue infections was noted between countries and continents, with the overall rate highest in North America at 36 percent compared with Latin America at 29 percent in the SENTRY study<sup>[17]</sup>



**Skin infection prevention**

Ways of reducing the risk of a skin infection or rash include:

washing regularly

drying the body to remove all moisture

avoiding sharing personal items with other people

checking the skin regularly for changes and seeking advice as soon as signs of infection appear

having the recommended vaccinations to prevent diseases such as chickenpox<sup>[18]</sup>

**V. TREATMENT FOR BACTERIAL SKIN INFECTIONS DISEASE**

Some infections will go away on their own or respond to over-the-counter creams.

If an infection is severe, the person is at risk of complications, or the infection is contagious, a doctor may prescribe medication such as:

antibiotics

antivirals

antifungals



antiparasitic

The form of the medication will partially depend on the severity of the infection or the risk of complications. A person with a severe infection may need to spend time in the hospital.<sup>[19]</sup>

An antibiotic ointment is used if a minor skin infection develops. Antibiotics also need to be taken by mouth or given by injection if a large area of skin is infected. Abscesses should be cut open by a doctor and allowed to drain, and any dead tissue must be surgically removed.



### Treatment for Acute skin infections

Bacterial skin infections are commonly encountered infection in various healthcare settings<sup>20</sup>

Over the last 2 decades community-associated methicillin-resistant *Staphylococcus aureus* MRSA has emerged as the most common cause of purulent skin infections in the United States with accompanying higher rates of complications, recurrence, and treatment failure often leading to hospitalization

The overall burden of managing such common infections has resulted in added healthcare costs<sup>[21]</sup>

The US Food Drug Administration FDA definition of acute skin infections includes cellulitis major skin abscesses and wound infections with all requiring a minimum lesion surface area of 75cm<sup>[22]</sup>

Acute skin infection is a common reason for patients seeking care in various healthcare settings, including emergency departments<sup>23]</sup>

Most are treated effectively as outpatients, the decision-making process for admitting patients to the hospital for acute skin infection is complex and often very subjective in general. Patients with all of the following characteristics can be managed as outpatients, no sign of sepsis with low suspicion of deep soft tissue infection including necrotizing fasciitis and lack of exacerbation of comorbidities, for the majority of patients empiric treatment, is most often directed against gram-positive cocci<sup>24</sup>

During hospitalization, healthcare providers may need to reevaluate antimicrobial treatment and the need for surgical intervention<sup>25</sup>

Most recently, the Infectious Diseases Society of America published practice guidelines for the diagnosis and management of acute skin infections<sup>2</sup>

## VI. CONCLUSION

Today, there is still a need for epidermiological bacteriological surveys in the community for ‘superficial’ pyodermas i.e impetigo and furunculosis in order to evaluate more precisely the burden of CA-MRSA skin infections, especially in European countries, and to further target adequate preventive measures. Concerning erysipelas and another nonnecrotizing cellulitis, further studies evaluating home therapy either intravenously or orally, and shorter regimens are still mandatory for these common, mainly streptococcal, diseases.

## REFERENCES

- [1]. Stevens DL, Bisno AL, Chambers HF, et al. Practice guidelines for the management of skin and soft tissue infections. Clin Infect Dis 2005; 41:1373 –1406.
- [2]. <https://medlineplus.gov/skininfections.html>

- [3]. French Society of Dermatology. Consensus conference: management of erysipelas and necrotizing fasciitis. *Ann Dermatol Venereol* 2001; 128: 463–482.
- [4]. Heng MC, Khoo M, Cooperman A, Fallon-Friedlander S. Haemorrhagic cellulitis: a syndrome associated with tumour necrosis factor-alpha. *Br J Dermatol* 1994; 130:65–74.
- [5]. Albert, M.J.; Mathan, V.I.; Baker, S.J. Vitamin B12 synthesis by human small intestinal bacteria. *Nature* 1980, 283, 781–782. [CrossRef]
- [6]. WibkeKrüger 1,† , Sarah Vielreicher 1,† , Mario Kapitan 1,2, Ilse D. Jacobsen Maria Joanna Niemiec 1,2
- [7]. Alexander, H., et al. "The role of bacterial skin infections in atopic dermatitis: expert statement and review from the International Eczema Council Skin Infection Group." *British Journal of Dermatology* 182.6 (2020): 1331-1342.
- [8]. Edlich, Richard, Kathryn L. Winters, and Kant Y. Lin. "Breast cancer and ovarian cancer genetics." *Journal of long-term effects of medical implants* 15.5 (2005).
- [9]. Ilyas, Muneeb, et al. "Skin infections due to bacteria in solid organ transplant recipients: a review." *Dermatology* 233.5 (2018): 358-365.
- [10]. Krüger, Wibke, et al. "Fungal-bacterial interactions in health and disease." *Pathogens* 8.2 (2019): 70.
- [11]. <https://chat.openai.com/c/95c136ab-3bb3-4599-8759-baf7c3212881>
- [12]. LeBlanc DM, Reece EM, Horton JB, et al. Increasing incidence of methicillin-resistant *Staphylococcus aureus* in hand infections: a 3-year county hospital experience. *Plast Reconstr Surg* 2007; 119:935–940.
- [13]. Bahrain M, Vasiliades M, Wolff M, Younus F. Five cases of bacterial endocarditis after furunculosis and the ongoing saga of community-acquired methicillin-resistant *Staphylococcus aureus* infections. *Scand J Infect Dis* 2006; 38:702–707.
- [14]. Koning S, Verhagen AP, Van Suijlekom-Smit LW, et al. Interventions for impetigo. *Cochrane Database Syst Rev* 2004; 2:CD003261.
- [15]. Koning S, Van Suijlekom-Smit LW, Nouwen JL, et al. Fusidic acid cream in the treatment of impetigo in general practice: double-blind randomised placebo-controlled trial. *Br Med J* 2002; 324:203–206.
- [16]. Luby SP, Agboatwalla M, Feikin DR, et al. Effect of handwashing on child health: a randomized controlled trial. *Lancet* 2005; 366:225–233.
- [17]. Lubbe J. Secondary infections in patients with atopic dermatitis. *Am J Clin Dermatol* 2003; 4:641–54.
- [18]. Leyden JJ, Baker DA. Localized herpes simplex infections in atopic dermatitis. *Arch Dermatol* 1979; 115:311–12.
- [19]. Ong PY, Leung DYM. Bacterial and viral infections in atopic dermatitis: a comprehensive review. *Clin Rev Allergy Immunol* 2016; 51:329–37.
- [20]. Eyerich K, Pennino D, Scarponi C et al. IL-17 in atopic eczema: linking allergen-specific adaptive and microbial-triggered innate immune response. *J Allergy Clin Immunol* 2009; 123:59–66.
- [21]. Wollenberg A, Zoch C, Wetzel S et al. Predisposing factors and clinical features of eczema herpeticum: a retrospective analysis of 100 cases. *J Am Acad Dermatol* 2003; 49:198–205.
- [22]. Beck LA, Boguniewicz M, Hata T et al. Phenotype of atopic subjects with a history of eczema herpeticum. *J Allergy Clin Immunol* 2009; 124:260–9. dermatitis
- [23]. Bin L, Kim BE, Brauweiler A et al. *Staphylococcus aureus* a-toxin modulates skin host response to viral infection. *J Allergy Clin Immunol* 2012; 130:683–91.
- [24]. Gomes PLR, Malavige GN, Fernando N et al. Characteristics of *Staphylococcus aureus* colonization in patients with atopic dermatitis in Sri Lanka. *Clin Exp Dermatol* 2011; 36:195–200.
- [25]. Morita E, Hide M, Yoneya Y et al. An assessment of the role of *Candida albicans* antigen in atopic dermatitis. *J Dermatol* 1999; 26:282–7.
- [26]. Beck LA, Boguniewicz M, Hata T et al. Phenotype of atopic dermatitis subjects with a history of eczema herpeticum. *J Allergy Clin Immunol* 2009; 124:260–9