



Bacterial Skin Infections: Epidemiology and Latest Research

Bakteriyel Cilt Enfeksiyonları: Epidemiyoloji ve En Son Araştırmalar

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ABSTRACT

Skin infections are very common throughout the world. The prevalence of skin infections has been reported as follows: pyoderma (prevalence range 0.2-35%, 6.9-35% in Sub-Saharan Africa), tinea capitis (1-19.7%), scabies (0.2-24%, 1.3-17% in Sub-Saharan Africa), viral skin disorders (0.4-9%, mainly molluscum contagiosum), pediculosis capitis (0-57%). Bacterial skin infections are the most common type of skin infections. The most common bacterial skin infections are reported as impetigo, folliculitis, furunculosis and abscesses, cellulitis, scarlet fever, erysipelas, erythrasma, necrotizing fasciitis and some others. In addition to these, ecthyma, carbunculosis, and mycobacterium skin infections are discussed in this review. The latest research gives us the information on the recent change in the bacterial etiology and treatment of bacterial skin infections. The increase in methicillin-resistant *S. aureus* (MRSA) in impetigo has recently shown us the necessity of being more careful in regard to its treatment. There are also new measures to prevent skin infections, such as the use of maternal zinc supplementation.

Key words: Epidemiology, skin infections, bacterial, latest, research

ÖZET

Cilt enfeksiyonları tüm dünyada yaygın olarak görülmektedir. Cilt enfeksiyonlarının prevalansı sırasıyla: piyoderma (prevalans aralığı %0,2-35, Sahra Altı Afrika'da %6,9-35), tinea kapitis (%1-19,7), skabies (%0,2-24, Sahra Altı Afrika'da %1,3-17), viral cilt sorunları (%0,4-9, esas olarak molluskum kontagiozum), pedikülozis kapitis (%0-57) olarak bildirilmiştir. Bakteriyel cilt enfeksiyonları en sık görülen cilt enfeksiyonu tipidir. En sık görülen bakteriyel cilt enfeksiyonları impetigo, follikülit, furonkülozis ve abse, selülit, kızıl, erizipel, eritrazma, nekrotizan fasiit ve bazı diğer enfeksiyonlardır. Bunlara ek olarak, ektima, karbonkül ve mikobakterium cilt enfeksiyonları da bu derlemede tartışılmıştır. En son araştırmalar bize bakteriyel cilt enfeksiyonlarının etiyojisi ve tedavisinde yakın zamanda olan değişikliklerin bilgisini vermektedir. İmpetigoda metisiline dirençli *S. aureus* (MRSA) artışı, yakın zamanda bize bunların tedavisinde daha dikkatli olmamız gerektiğini göstermiştir. Ayrıca, anne kaynaklı çinko desteği verilmesi gibi cilt enfeksiyonlarının önlenmesinde yeni öneriler bulunmaktadır.

Anahtar kelimeler: Epidemiyoloji, cilt enfeksiyonları, bakteriyel, en son, araştırma

INTRODUCTION

Skin infections are very common throughout the world, and family physicians, dermatologists and many other specialty doctors treat these infections frequently during their daily practice. The prevalence of these infections may vary from one region to another. Therefore, it can be difficult to single out one of these infections as the most common. According to the report of the World Health Organization on the Epidemiology and Management of Common Skin Diseases in Children in Developing Countries in 2005, the prevalence of skin infections was stated as follows: pyoderma (prevalence range 0.2-35%, 6.9-35% in Sub-Saharan Africa), tinea capitis (1-19.7%), scabies (0.2-24%, 1.3-17% in Sub-Saharan Africa), viral skin disorders (0.4-9%, mainly molluscum contagiosum), pediculosis capitis (0-57%).¹ This report shows us that the most common skin infection was bacterial, followed by fungal, parasitic and viral infections in children. In another study in which adults were included, fungal infections were the most common presentation (39.0%) and males were more commonly affected than females.² Some of the skin infections may be attributed to poor hygienic conditions, which may be more prevalent in developing countries. However, bacterial, fungal and viral skin infections are common throughout the world even in developed countries with the best hygienic standards. It has been reported that skin infections (bacterial, viral, fungal) make up 42-65% of the total skin morbidity in children in general practice.³⁻⁶

This article will summarize the latest information on the epidemiology of bacterial skin infections by giving the data of mostly the last decade on the most common bacterial skin infections and their features in both developing and developed countries.

BACTERIAL SKIN INFECTIONS

Andrews et al. reported that more than 111 million children in the world are believed to have pyoderma, with many also co-infected with scabies, tinea, or both.⁷ There are many kinds of bacterial skin infections. The most common are reported as impetigo, folliculitis, furunculosis and abscesses, cellulitis, scarlet fever, erysipelas, erythrasma, necrotizing fasciitis and some others.⁸ In addition to these, ecthyma, carbunculosis, and mycobacterium skin infections will be discussed in this section.

Impetigo

The reported prevalence of impetigo is 10% of all skin problems seen in general dermatology clinics (Figure 1). The importance of this infection is that the incidence of acute nephritis with impetigo varies from 2% to 4%^{9,10} This may result in 1-2 million new cases of nephritis each year. Impetigo occurs both in children and adults and there

is no gender difference in children, whereas men are affected more commonly than women. The bullous form is most common in infants and preschool children, and the nonbullous form may be seen at any age. Streptococcal impetigo is reported as being more common in warm, humid environments and in tropical or subtropical climates, whereas *S. aureus* impetigo is more common in temperate climates and in summer.^{9,11} It may be seen both in healthy people with good living conditions and in people living in overcrowded, poor hygiene conditions. The increase in methicillin-resistant *S. aureus* (MRSA) in impetigo has recently shown us the necessity of being more careful with regard to its treatment. Impetigo is contagious among family members and in case of contact sports.⁹ Therefore, washing the hands frequently, cutting the fingernails short, and staying away from school for 24 hours after the start of antibiotics is suggested. The guideline for wrestlers requires that they: (1) have no new lesions within the past 48 hours, (2) have completed 72 hours of antibiotic treatment, and (3) have no moist, exudative, or draining lesions at tournament or practice.^{9,11-13} In 2009, a wrestler was disqualified because of not having undergone adequate treatment for MRSA impetigo.¹⁴ Shim et al. recently reported that although evidence is lacking to support a single best treatment for impetigo, topical mupirocin, fusidic acid, gentamicin, and retapamulin are all at least 20% more likely than placebo to produce cure or improvement.¹⁵ Shigemura et al. reported the case of a 32-year-old Japanese woman with neutrophil-specific granule deficiency who had a small impetigo lesion on her face and experienced the rapid spread of a facial abscess to a pulmonary abscess via the blood stream.¹⁶ It was also reported that molluscum contagiosum cases were more likely to have a prior or co-occurring diseases, including impetigo, compared to controls.¹⁷

Summary of latest research on impetigo

Hayashida et al. reported that the odds of having a history of impetigo contagiosa were 1.8 times higher in children with atopic dermatitis than in children with non-atopic dermatitis.¹⁸ Nasr et al. reported that the epidemiology of postinfectious glomerulonephritis is shifting as the population ages, and the most common site of infection was the skin in these elderly population.¹⁹ Berries and Arbiser reported that given their low cost, ease of application, and favorable side effect profile, triphenylmethanes must be considered as legitimate treatment options for pyodermas, particularly in the face of continued and emerging bacterial resistance.²⁰ Dalager-Pedersen et al. reported that *S. aureus* infections and dicloxacillin prescriptions more than doubled in primary healthcare during the 12-year study period in skin and soft tissue infections.²¹ Hisata et al. reported that in 3 months they had characterized 17 MRSA strains isolated from children with impetigo at a Japanese hospital.²² In another study, Rortveit et al. reported that *S. aureus* resistance to

fusidic acid in relation to impetigo is now less frequent in this population than at the start of the century, and at present, most *S. aureus* bacteria resistant to fusidic acid in impetigo belong to the European fusidic acid-resistant impetigo clone.²³ Iovino et al. reported that NVC-422 topical gel administered TID was well tolerated, with high rates of clinical and microbiological responses for treating impetigo.²⁴ Darmstadt performed a study to determine the effects of maternal zinc supplementation on skin infections among infants in poor urban areas of Dhaka, Bangladesh.²⁵ In this study they found that the effect of zinc supplementation was more pronounced in male infants (64% reduction), intrauterine growth restricted and low birth weight infants (73% reduction), and in infants of mothers with increased parity (60% reduction) or decreased socioeconomic status (71% reduction).

Koning et al. conducted a meta-analysis of the treatment choices for impetigo. They reported that there was good evidence that topical mupirocin and topical fusidic acid were equally, or more, effective than oral treatment.²⁶ Due to the lack of studies in people with extensive impetigo, it was unclear if oral antibiotics were superior to topical antibiotics in this group. Fusidic acid and mupirocin were of similar efficacy. Penicillin was not as effective as most of other antibiotics. It has also been stated that there is a lack of evidence to support disinfection measures to manage impetigo. In contrast to this study, Rijnders et al. reported different results. They stated that the usefulness of fusidic acid as first-line agent for the treatment of impetigo was questionable.²⁷ As mupirocin is used in the Netherlands for eradication of MRSA, it is not an alternative; retapamulin might be useful, but further *in vivo* studies are warranted. Bolaji et al. reported that in the USA, oral antibiotics were the most common class of medications used to treat impetigo, and there is an opportunity for physicians to take advantage of equally efficacious topical antibiotics for treating impetigo.²⁸ They also stated that a shift towards topical antibiotics would likely decrease the morbidity (resulting from adverse effects) associated with the use of oral agents.²⁸ In a recent study, ozenoxacin 1% cream was found to be effective and safe in the treatment of impetigo.²⁹

Ecthyma

Ecthyma is defined as a cutaneous infection that extends deep into the dermis and heals with scarring. It usually develops over disrupted skin on the extremities and rapidly develops into a vesicopustule and finally a hemorrhagic crust. In the 1970's it was believed that only immunosuppressed or gravely ill patients were affected by ecthyma. In the 1980's, many microorganisms were thought to cause ecthyma. Ecthyma is characterized by two forms.

1. *Ecthyma gangrenosum (EG)*: This form occurs as a gangrenous ulcer with a central eschar surrounded by an

erythematous halo (Figure 2). Pseudomonal infections are responsible for this form and it occurs in immunosuppressed or gravely ill patients.³⁰ This form is identified as pseudomonal EG.³¹ *Aeromonas hydrophila*, *S. aureus*, *Serratia marcescens*, *Aspergillus* spp. and *Mucor* Disseminated candidiasis have also been reported to cause skin lesions mimicking EG and are called as nonpseudomonal EG.³² Pseudomonal EG causes mortality because of septicemia in the immunosuppressed which ranges from 38% to 77%, whereas mortality in nonbacteremic EG is 15%.^{33,34}

EG is clinically important because it is a sign of the presence of a predisposing factor or causes clinically severe outcome. It can also occur in healthy individuals and can be a first sign of a serious disease. EG should be suspected based on clinical appearance, the lesions should be cultured, and systemic antibiotic therapy with coverage for pseudomonas should be started immediately. Also, topical antiseptic agents have been recommended for treating burn wounds infected with pseudomonas.³⁵

2. *Ecthyma contagiosum (EC)*: This form presents with solitary pustular lesions on the hands. It is called as orf, the infection being transmitted from infected animals. A virus of the parapoxvirus group and other infectious microorganisms are responsible for this form. It generally occurs in damaged skin from contact with an infected animal.³⁰ It can be seen in all countries of the world. The incubation period is 3-7 days. In immunocompetent patients, contagious ecthyma is usually self-limiting. Treatment is supportive and typically consists of moist dressings, local antiseptics, finger immobilization and/or antibiotics to treat secondary bacterial infections. Large lesions can be removed by surgery, and curettage and electrodesiccation may be used for persistent lesions. Cryotherapy is also used for treatment.³⁶

Summary of latest research on ecthyma

Cohen et al. concluded that, EG may be a sign of predisposition to a serious clinical disease. In particular, they suggested that, clinical and laboratory assessment is important after EG.³⁷

Vaiman et al. declared that necrotic lesions of the skin diagnosed as EG have various microbiological etiologies, and it is not necessarily advised to differentiate them as pseudomonal and non pseudomonal EG.³⁸ These two forms of the disease are similar in terms of treatment.

Folliculitis, furunculosis, and carbuncle

Folliculitis is defined histologically as the presence of inflammatory cells within the wall and ostia of the hair follicle, creating a follicular-based pustule (Figure 3).³⁹ The inflammation can be limited to the superficial aspect of the follicle with the infundibulum or the inflammation can affect both the superficial and deep aspect of the

follicle. Deep folliculitis can result from the chronic lesions of superficial folliculitis or from lesions that are manipulated, and this may ultimately result in scarring.

The incidence and prevalence of folliculitis are unknown, because the disease is often self-limited and patients rarely present to the doctor. Complications in folliculitis are uncommon. Cellulitis, furunculosis, scarring, and permanent hair loss may occur. The Folliculitis can be seen in all age groups. Some microorganisms can differ according to gender.⁴⁰

Furuncles are filled bumps on the skin and result from deep infection of a hair follicle (Figure 4). *S. aureus* is usually responsible. Some people are "carriers" of the *S. aureus* germ and this lives on their skin or in their nose without doing them any harm. Friction or scratching the surface of the skin allows the germ to enter and infect the hair follicle and inflammation begins.

Furuncles may resolve, but the infected fluid needs to drain completely. Many furuncles drain of their own accord. Antibiotics may be prescribed. Untreated furuncles can enlarge or grow together to form a giant multi-headed (carbuncle). Rarely, the infection in the skin can get into the bloodstream, leading to serious illness. Athletes, immunosuppressed patients, people with other skin conditions, staphylococcus carriers, obese people, and those with poor nutrition are risk groups.

A carbuncle consists of several furuncles, and goes much deeper into the skin. It consists of small, shallow abscesses that connect with each other under the skin (Figure 5). A carbuncle usually occurs on the back of the neck or side of the thigh. It may easily burst, drain pus, and form an ulcer on the skin. The skin then slowly heals and a deep scar may develop. It causes many symptoms, such as fever, chills, fatigue, or pain. Oral and local forms of antibiotics and drainage of the abscesses are used for treatment.^{40,41}

Summary of latest research on folliculitis, furunculosis, and carbunculosis

The most important thing about furunculosis is its recurrence. The recurrent form of furuncles has been observed in travelers from the tropics in case series.⁴¹ In the study of Davido et al. the authors concluded that the CMA protocol (skin disinfection (chlorhexidine), local nasal antibiotic (mupirocin), and systemic antibiotic (clindamycin) is effective and safe for recurrent forms.⁴²

Erysipelas, cellulitis and necrotizing fasciitis

Erysipelas is considered as involving the superficial dermal structures and is distinguished by well demarcated raised borders.⁴³ Erysipelas is also defined as a special form of cellulitis that is limited to the surface layers of the skin (Figure 6).

Cellulitis is defined as any spreading infection involving the dermis and subcutaneous tissues (Figure7).⁴⁴ The incidence of erysipelas is 10 to 100 cases per 100 000 persons per year.⁴⁵ Typically, the age of onset of the conditions is between 40 and 60 years and those with diagnosed with cellulitis account for between 1% and 14% of patients in emergency departments.⁴⁶ Whereas erysipelas affects the face, cellulitis mostly affects the lower limbs of the subjects.^{46,47}

Bacteremia associated with erysipelas and cellulitis generally indicates that streptococcal species are the predominant pathogens. *S. aureus* is responsible for a much smaller proportion. Importantly, gram-negative organisms appear to be at least as common as *S. aureus*.⁴⁸

Necrotizing fasciitis (NF) is a soft-tissue infection with rapidly progressive, widespread fascial necrosis. It can spread to the epidermis, dermis, fascia, adipose tissue and muscle. NF can be an infection of one species of bacteria or may be polymicrobial. The most commonly identified microorganism is streptococcus. NF may occur on the site of a skin biopsy, laceration, insect bite, needle puncture (especially in illicit drug users), herpes zoster, surgical wound, skin abscess, or areas affected with a chronic venous leg ulcer. Diabetes mellitus, old age, surgery, trauma, chronic skin infection, and immune system impairment are the risk factors. However, half of infected patients are young people.

Prompt diagnosis and treatment are essential. The most important thing is recognizing the NF and starting treatment as soon as possible. Broad-spectrum antibiotics, wide surgical debridement, and supportive care are used in its treatment. Despite appropriate treatment, the mortality rate is between 25-35%.⁴⁹

Summary of latest research on erysipelas, cellulitis and necrotizing fasciitis

Ford et al. declared that varicella infection together with NSAID usage may be predisposing factors for group A streptococcal NF. Due to routine varicella zoster immunization in children, the rate of NF has decreased in Canada.⁵⁰ Sturgeon et al. declared that chicken pox is common and self-limiting, but it can be complicated by NF, with a 3.4% mortality rate.⁵¹ Complication with or progression to streptococcal toxic shock syndrome complicates 37% of NF infections in varicella zoster virus, with a 4-fold increase in mortality rate. Shaw et al. suggested that hyperbaric oxygen therapy is associated with a significant survival benefit.⁵² Use of hyperbaric oxygen therapy with current practices for the treatment of NF can be both a cost-effective and life-saving therapy. Mondello et al. declared that in multiple myeloma patients treated with biphosphanate, corticosteroids and antiangiogenetic drugs there may be a slight risk of osteonecrosis and NF.⁵³

Erythrasma

Erythrasma is a chronic bacterial infection due to *Corynebacterium minutissimum*. Clinically it affects the interspaces of the toes, the axillary folds and the groin (Figure 8). It is usually diagnosed as a dermatophytic infection.⁵⁴ In Turkey, in patients with interdigital foot lesions, the prevalence of erythrasma is 46.7%. The disease is more prevalent in men.⁵⁵

Erythrasma is usually seen in patients with diabetes mellitus. The differential diagnosis of erythrasma includes psoriasis, dermatophytosis, candidiasis and intertrigo. Wood's light examination and bacterial and mycological cultures are used for differentiation purposes. Erythromycin 250 mg four times daily for 14 days is the treatment of choice and other antibacterials include tetracycline and chloramphenicol. Systemic erythromycin treatment demonstrates cure rates as high as 100%. Topical solutions such as clindamycin, Whitfield's ointment, sodium fusidate ointment and antibacterial soaps may be required for both treatment and prophylaxis.⁵⁶

Summary of latest research on erythrasma

Avci et al. declared that topical fusidic acid proved to be the most effective treatment; however, clarithromycin therapy may be an alternative regimen in the treatment of erythrasma because of its efficiency and better patient compliance.⁵⁷

Mycobacterium Skin Infections

Atypical mycobacteria are different from *M. tuberculosis* and *M. leprae* and are called non-tuberculous mycobacteria (NTM). Atypical mycobacteria have almost thirty different variants. Mycobacterium infections with NTM have been increasingly described, especially in immunosuppressed patients. Also immunocompetent patients can be infected because of iatrogenic etiology. Mycobacterium skin infections occur when the skin's integrity is disrupted due to surgery, deep wounds or after trauma.

Atypical mycobacterial infections usually cause slow clinical symptoms and are self-limited. However, *M. ulcerans* and *M. scrofulaceum* cause destructive and deep skin infections. The complex of *M. kansasii*, *M. szulgai* or *M. fortuitum*–*chelonae* infections can spread to the tendon and bone tissue with clinical severity.⁵⁸

Infection can occur after fishing, swimming in swimming pools, aquarium management, and medical and anaesthetic procedures for quick-growing mycobacteria. The incubation period varies between 2 weeks and 9 months. A small reddish papule normally appears at the inoculation site. The lesion grows slowly, and similar lesions can grow and progress along the path of the lymphatic vessels. It is possible to distinguish three

different clinical patterns in accordance with the clinical evolution of the disease. First, a unique lesion occurs at the inoculation site. After this, multiple lesions with sporotrichoid morphology are determined and deeper infections with involvement of subcutaneous structures occur. The outcome of the lesions is strictly linked to the characteristics of the infecting mycobacterium and to the immunologic conditions of the host.^{59,60} In order to diagnose mycobacteria infections, a culture test is performed. The Loewenstein-Jensen test is the one most commonly used. The other methods are histopathology and, if available, biomolecular diagnostic techniques.^{61,62}

Uslan et al. reported that *M. chelonae* or *M. abscessus* infections were more common in older patients and in those taking immunosuppressive medications.⁶³ *M. fortuitum* tends to manifest as a single lesion, while most *M. chelonae* or *M. abscessus* manifested as multiple lesions in patients. The spectrum of infectious agents is usually varied according to geographic distribution. In Spain, *M. fortuitum* complex was isolated in 69%, *M. avium* in 23% and *M. marinum* in 8% of cases.⁶⁴ Bartralot et al. isolated *M. marinum* in 78%, *M. chelonae* in 11% of the patients.⁶⁵ *M. marinum* was isolated at a high rate in the Middle East region.⁶⁵

Treatment includes a combination of different antimicrobial agents, but it must be taken into account that NTM are resistant to conventional antituberculous drugs. Severe cases or those with deep tissue involvement could also be due to surgical resection.⁶⁶ Treatment is difficult because many atypical mycobacteria are resistant to common antibiotics.⁶⁷

Summary of latest research mycobacterium skin infections

NTM infections are becoming increasingly recognized in recipients of hematopoietic stem cell transplantation with incidence rates ranging between 0.4 and 10%. These infections are 50-600 times commoner in transplant recipients than in the general population and the time of onset ranges from day 31 to day 1055 post-transplant.⁶⁸

El-Khalawany et al. concluded that the diagnosis of mycobacteria skin infection is based mainly on culture and polymerase chain reaction (PCR); other clinicopathological features such as history of trauma, acral location of the lesion and suppurative granulomatous reaction with intrafollicular abscesses could be helpful clues in suspecting mycobacteria skin infection.⁶⁵

Luz et al. concluded that lymphadenitis caused by NTM is an uncommon manifestation in immunocompetent individuals. However, varicella zoster virus infections may cause immune suppression and in these cases, lymphadenitis may be a sign of NTM infections.⁶⁹

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Figure 1. Impetigo: Red papules with adherent yellowish squam.



Figure 2. Ecthyma: Erythematous, well demarcated border, peripheral hemorrhagic crust and central erosion



Figure 3. Folliculitis: Multiple follicular pustules that coalesce



Figure 4. Furuncles: Erythematous red nodule with pustules



Figure 5. Carbuncle: Necrotic crust on well defined-bordered ulcer surrounded by erythematous plaque



Figure 7. Cellulitis: Erythematous elevated plaque, with uncertain border



Figure 6. Erysipelas: Erythematous, sharp bordered, shiny macules



Figure 8. Erythrasma: Well defined reddish brown macule

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