



The skin commensal *Staphylococcus epidermidis*, is a boon or bane?

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Abstract

Skin is an active immune organ, which protects the human internal organs from biotic and abiotic hazards. *Staphylococcus epidermidis* is a primary bacterial colonizer of the skin and one of the most abundant microorganisms among the other skin microbiome. Moreover, this bacterial sp. is considered as an active microbiological barrier of the skin and one of its defensive components. On the other side, *S. epidermidis* is a causative agent of serious infections including wound infections, and bacteremia. The aims of the current mini-review were to attract the attention of the scientific community to this perplexing bacterium, and to develop an enhanced understanding about the role of this microorganism in the skin. Furthermore, it is necessary to understand the relationship between the protective mechanisms of this bacterium in the human skin, and to realize the influences that direct this bacterium to turn from a useful commensal to a serious contagion.

Keywords: *Staphylococcus epidermidis*, Nosocomial infections, Skin infections, Normal flora, Microbiome

1. Introduction

Skin is the largest organ of the human body. It is complicated and composed of three layers including: the epidermis, dermis, and subcutaneous tissue. A recent study conducted by [Nguyen and Soulika, \(2019\)](#) highlighted that the skin has many functions, but the most important one is protection of the body from microbial invasion; by acting as physical, chemical and biological barrier. Commensal skin microorganisms are the actual biological barriers. Millions of bacteria, fungi and viruses design the normal flora of the skin. The micro-environment of the skin can be classified into four sites mainly: moist,

dry, oily and foot. According to [Byrd et al., \(2018\)](#), *Propionibacterium acnes*, *Staphylococcus epidermidis* and eukaryotic DNA viruses are among the most common skin microbiomes. There are also convoluted interactions between the skin microbiome and the immune cells within the intricate associations between them, which are influenced by the physiological changes of the host in addition to the environmental challenges ([Belkaid and Segre, 2014](#)). This could drive us to think about the relationships between maintaining a good health and the status of our microbiome; particularly the skin microbiome. The

objective of this study was to draw attention to the importance of preserving skin microbiome; taking *S. epidermidis* as a substantial model.

2. Skin microbiome and infections

As previously mentioned, skin is the first defensive line of the body; accordingly, it is the first target for pathogens. A previous study of [Stulberg et al., \(2002\)](#) reported that common bacterial skin infections comprise folliculitis, erysipelas, impetigo, cellulitis, furuncles and carbuncles. Interestingly, skin harbors a massive population of T-cells. It is estimated that about 20 billion of T-cells are found in the entire human skin ([Koguchi-Yoshioka et al., 2021](#)), whereas trillions of microorganisms live on the skin, thus there should be a robust relationship between the commensal microbial skin and the entire immune system. This ambiguous relationship did not find its luck from extensive studies, although it could improve the ability of the skin to fight pathogenic invaders. A closer look to mammal's body shows that the animal skin is important and supports its fitness, as reported by the study of [Lavrinienko et al., \(2018\)](#). Moreover, the skin of mammals is able to respond to various environmental cues, and is greatly affected by geography rather than the level of natural radionuclides in the soil. Accordingly, a recent study of [Lavrinienko et al., \(2018\)](#) concluded that there is a correlative relationship between the skin microbiome and the gut microbiota in mammals. A previous genomic study carried out by [Grice and Segre, \(2011\)](#) that depended on the analysis of the bacterial 16S rRNA gene sequence, revealed that the majority of skin bacteria are located within four phyla namely: Proteobacteria, Actinobacteria, Bacteroidetes and Firmicutes. These phyla are approximately similar to those found in the alimentary canal, colon and oral cavity, but with different proportions and vast diversity of species, as reported by [Grice and Segre, \(2011\)](#). It is believed that there is a crosstalk between the immune system of the biotic barriers on the skin surface and the local skin microbiome, in a mode of multifold interactions. This is an intrinsic key for future development of therapeutic interventions

targeting the skin microbiome; to tackle the dermal diseases and disorders. However, the mechanisms of these interactions are poorly studied so far ([Zheng et al., 2020](#)). Finally, it is important to mention that, many skin disorders and diseases could be attributed to the imbalance or dysbiosis between the skin microbiome and the immune system barriers of the skin, which may influence homeostasis and keratinocyte regulation, as revealed by the previous study conducted by [Beri, \(2018\)](#).

3. General features of *S. epidermidis*

The genus *Staphylococcus* comprises about 30 species, about 10 of them are considered as human commensals. Amongst them, *S. aureus* and *S. epidermidis*; are the major causative agents of several skin diseases, ranging from mild to life-threatening infections ([Massey et al., 2006](#)). *S. epidermidis* bacterium is a Gram-positive cocci (Fig. 1); facultative anaerobe, non-spore forming, non-motile and biofilm-forming. Moreover, they are coagulase-negative, which is one of the tests that differentiate between this species and *S. aureus* (coagulase-positive), as highlighted in the previous study of [Namvar et al., \(2014\)](#). *S. epidermidis* is also non-haemolytic on blood agar, gives positive weak reaction in the nitrate reductase test, oxidase negative, urease positive, gas producer in the presence of lactose and sensitive to novobiocin, which differentiates it from *S. saprophyticus* (Novobiocin-resistant) ([Anonymous, 2021](#)).

4. Is *S. epidermidis* a foe or a friend?

An early study conducted by [Massey et al., \(2006\)](#) revealed that *S. epidermidis* is a part of the skin microbiome, and it is believed that presence of this bacterium on the skin surface may prevent its colonization by the pathogenic microorganisms, but the mechanism is still ambiguous. Recently, [Claude et al., \(2019\)](#) reported that *S. epidermidis* has a beneficial role in treatment of acne by limiting *Cutibacterium acnes* (The main trigger of acne) over-colonization and inflammation.

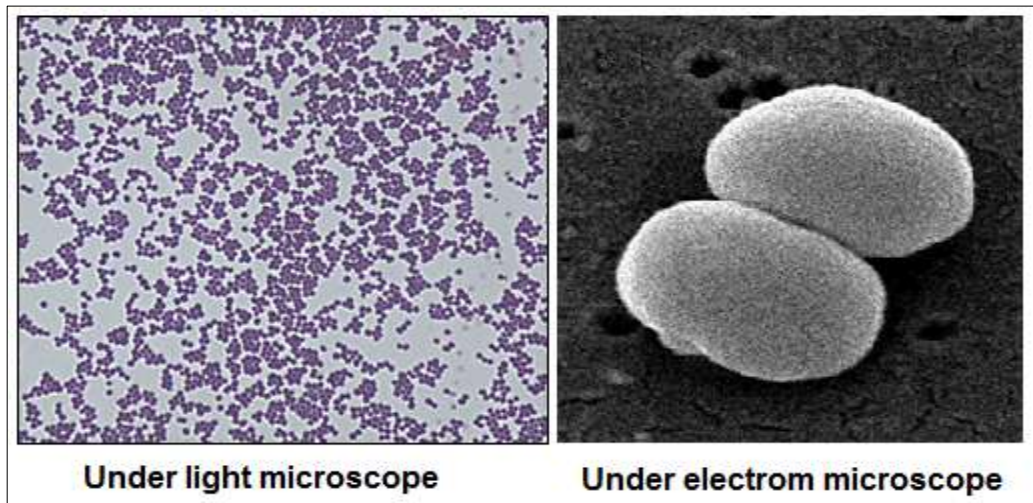


Fig. 1. Morphology of *S. epidermidis* cells. Sources: <https://commons.wikimedia.org/w/index.php?curid=29000633> (Light microscope), https://en.wikipedia.org/wiki/Staphylococcus_epidermidis (Electron microscope)

Figure (2) demonstrates some potential benefits of the commensal *S. epidermidis* on the skin, and also shows the possible pivotal role of the skin

microbiome related to the other biotic and abiotic cues.

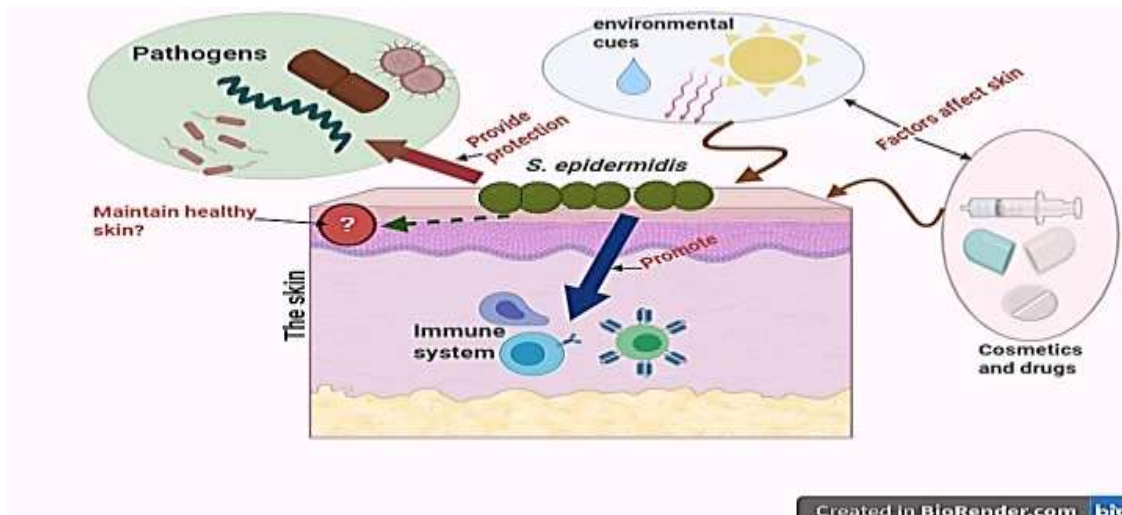


Fig. 2. Potential roles of *S. epidermidis* on the skin

Nonetheless, numerous clinical studies conducted by [Bes, \(1994\)](#); [Diekema et al., \(2001\)](#); [Gomes et al., \(2014\)](#) classified *S. epidermidis* as hard to treat its nosocomial infection, and also showed great resistance to several antibiotics. [Ziebuhr et al., \(2006\)](#) reported that *S. epidermidis* strains isolated from hospitals were different in some characteristics; as these isolated strains showed noticeable antibiotic resistance and formation of biofilms, which made these strains difficult to treat. Furthermore, molecular studies showed that these nosocomial strains possess high genome flexibility and mobile DNA elements, and future outbreak of virulent strains of *S. epidermidis* is expected. An early research work conducted by [Christof von Eiff et al., \(1998\)](#) revealed that 3 groups of patients are particularly susceptible to infection by *S. epidermidis* including: the intravenous drug users, the immune-compromised patients, and the patients indwelling or implanted foreign polymer bodies. On the other side, previous reports of [Yamasaki et al., \(2010\)](#); [Cogen et al., \(2010\)](#) claim that the commensal *S. epidermidis* can perfectly modulate the host innate immune response. Accordingly, the commensal strains of *S. epidermidis* maintain the skin health by means of convoluted mechanisms, and more deep investigations on this issue are highly requested.

Conclusion

Healthy skin is important for a healthy body as a whole. Skin is the largest human organ and is the first defensive line in the body, which plays an essential role in the innate and adaptive immune system. The surface of skin in an adult contains approximately 20 billion T-cells, meaning that skin may play essential role in boosting the immune system of the body. However, we still do not know yet about this role, due to the lack of studies concerned with the importance and the mysterious relationships between skin microbiome and the

entire immune system. *S. epidermidis* is one of the typical normal floras of the skin, and its role in immune system requires more studies. Accordingly, more investigations and scientific researches should focus on the relationship between skin microbiome and the negative impacts of several factors on the skin health and immune-system including; environmental stresses, misuse of drugs and cosmetics, pollution, immunodeficiency disorders, modern life style, dietary behavior and personal hygiene. Finally, we think that these stresses may have direct impacts on turning this bacterium i.e. *S. epidermidis* and other skin commensals from a blessing to a curse.

Conflict of interest

The author declares to have no conflict of interests.

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Ethical approval

Non-applicable.

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