Common skin disorders: A review

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ABSTRACT

Skin disorders are related to the dysfunction of skin’s components or layers defects of human skin. It has targeted all kinds of people regardless of age, gender, race, as well as social and economic status. Majority of the global population is affected by skin disorders to some extent this includes the three main categories namely dry skin, acne and hyperpigmentation. Because of the magnitude of the impact on the world population, this paper reviews skin disorders by looking three most common types which have become a great focus in many research works. The design of the review begins with profiling of literatures for a span of 20 years from 1999 to 2019 to accentuate the growing interest among research community in skin study. Skin anatomy is presented with focus on epidermis, dermis, skin turnover and the varying perspectives as well as the mechanical properties such as stress, strain, and absorption. On skin disorders, the number of literatures published for dry skin was found the highest and this is consistent with findings in other studies. Three skin disorders (dry skin, acne, and hyperpigmentation) have been critically reviewed by its physical evaluation and distinctive description. Etiologies of skin disorders are also reviewed and analyzed using relevant quality control tools.
1.0 INTRODUCTION

Tribology is a study that concerns with friction, wear and lubrication in many applications. "Tribo-" in Greek means rubbing and "-logy" means study. Hence, in layman term, Tribology is the study of rubbing of many interacting systems around us. Rubbing is a specific type of motion which is the heart of Mechanical Engineering study where people learn different facets of motion as observed in the behaviors of solid, fluid, semi-solid, and heat among others. Tribology is often defined as the science and technology of interacting surfaces in relative motion (Bhushan, 2013). Some of the key words of focus in grasping the concept of tribology is rubbing, interacting surfaces, and relative motion. When a system is in operation and rubbing of surfaces takes place, the system would response in certain ways and among the many concerns is the onset of friction and the subsequent wear and tear.

In a bigger perspective, any interacting surfaces in relative motion can be considered in tribology study and this makes tribology multidisciplinary, having a wider application horizon. It draws on various academic fields, including physics, chemistry, engineering, science of materials and biology. One field that has captured the interest of many researchers around the globe is Skin Tribology. There are many instances where interactions of skin in a defined system become a concern. The current interests and work of the authors on skin are described in three areas: (1) Fabrics-skin interactions and the issue of comforts, (2) Cosmetic effects on skin, and (3) Management of skin disorders using appropriate skin care products and cosmetics. In the context of skin tribology, wear and tear of skin manifests as aging and skin disorders while introduction of skin care and cosmetics offers solution in managing skin aging and disorders. Skin care products are used partly to lubricate skin surfaces just like oil lubricant deployed mainly to reduce friction between interacting surfaces of machine components in creating more efficient system operations. Introduction of lubricating film is mainly to reduce friction and the context of its application has been described in many studies (Ab Latif et al., 2019; Syahirah et al., 2015; Ahmed et al., 2014; Kasolang et al., 2011). A review of skin disorders in this paper is partly to prepare for the current work on skin and cosmetics by the authors on three focuses namely Research Progress and Skin Facts, Skin Anatomy, and Skin Common Disorders.

2.0 RESEARCH PROGRESS AND SKIN FACTS

Analysis of the current research progress on skin disorders provides a basis to gauge the importance of this topic and the interests of research community over time. Skin disorders are related to the dysfunction of skin's components or defects found in the layers of human skin. Regardless of age, gender and race, many people around the globe are affected by skin disorders which include not only the people who suffer but also those who manage. The research trend on skin disorders for 20 consecutive years (1999-2019) is given Figure 1, describing the number of related publications over the specified time period. The trend was produced on Science Direct Searched Engine using keywords "common human skin disorders" and only focused on published research articles.

In Figure 1, it is convenient to segment the trend into three periods: (1) 1999-2002, (2) 2003 to 2010, (3) 2011 to 2019. The first period from 1999 to 2002 shows a declining trend in the total publications with a record of 746, 710, 663 and 582 for the respective years from 1999 to 2002. In the second period, there was a sudden surge in total publications in 2003 with 715 publications but this does not sustain when the number reduces to 675 in 2004. From 2003 to 2010, two dimples were observed, one in 2004 and the other in 2008 (676 publications). The rest of the
years within this second period are relatively improving. In the third period from 2011 to 2019, there is an upward trend with steeper slope indicating a very active research output. A distinctive jump in publications is observed from 2018 (1120) to 2019 (1421) with a difference of 301 publications. The trend may suggest that there are more people seeking help from qualified practitioners such as dermatologists, aesthetic physicists, and beauticians to manage their skin disorders. It may also indicate a growing awareness among people to be more beauty conscious in their lifestyles as their economy strengthens. The breakdowns of the data into respective main skin disorders are discussed in Section 4.0.

There are skin facts that are important in understanding and appreciating skin better. Skin is the largest organ part of the human body as it covers the entire body with a surface area of 2 m², average thickness of 1.2 mm, average volume of 3.5 dm³ and it takes about 16% of the body weight (Agache and Humbert, 2004). The role of human skin can be varied into specific functions and functions exerted in conjunction with other organs. The specific functions of the skin include protection from harmful things, which may come from external physical, mechanical and chemical forces. In one aspect, skin acts as a chemical barrier by limiting the entry of foreign substances, preventing water and depletion of endogenous fluids. One amazing fact about skin is its self-healing property where skin is able to, over time, maintain and repair itself except for appendages such as hair, nails, eccrine sweat glands, sebaceous glands and apocrine glands. Other skin functions exerted in conjunction with other organs are production of vitamin D, immune function, sensory function as well as regulation of body temperature. Skin is the first line of information and protection in the immunity cycle especially in delayed immunity (Agache and Humbert, 2004; Kolarsick and Goodwin, 2008; Nicol, 2005).

In its broader view, skin falls into two categories: glabrous skin and hair-bearing skin as shown in Figure 2(a) and (b) respectively (“Classifications of Skin,” 2015). Glabrous skin or non-hairy skin is typically found on the palms and soles, characterized by thick skin. Glabrous skin consists of stratified squamous epithelium to make skin wear and tear resistance while hair bearing skin has both sebaceous glands and hair follicles. Hair-bearing skin is the focus in this review paper as most skin disorders occur in this area. One of the common skin disorders faced by many people is acne which is due to a blockage of hair follicles in the departed skin cells (Reddy & Jain, 2019).
There is also a wide range of contradictory body sites which makes skin more intriguing to learn. For instance, the scalp with large hair follicles has only small vellus producing follicles although linked to large sebaceous glands and it is different from the forehead (Fu-Chan et al., 2005; Mcgrath et al., 2004). In the subsequent section, a discussion on Skin Anatomy is presented to highlight what constitutes human skins and how it works. Other main highlights are skin turnover time and skin components involved with the skin dysfunction.

3.0 SKIN ANATOMY

Skin has its own unique anatomy and that describes and determines its behavior and explains how it functions the way it does. Understanding skin anatomy also helps to put in context and clarify the common skin disorders reviewed in later section of this paper. It also helps to identify skin components which are dysfunctional and to plan for the right treatment. With the current interest of the authors, two of the three main layers of skin namely Epidermis and Dermis are subsequently discussed in the following subtopics.

3.1 Epidermis

Human skin consists of three layers as shown in Figure 2 and the outermost is called epidermis, giving the color skin that people see. Epidermis gives the first impression of a person and often the basis for categorizing people as fair or dark skin. Hence, the psychological effect of epidermis on people having skin disorders is tremendous. Epidermis is the thinnest layer of skin with approximately 0.01 cm thickness (Yusoff and Jaafar, 2012). What is epidermis? and How does it function to the benefits of human? Epidermis is made from specific constellation of cells known as keratinocytes, melanocyte, Langerhans cells and Merkel cells. Each type of cells has their own
roles in supporting the overall function of epidermis. Approximately, 90-95% of epidermal cells are keratinocytes designed to synthesize keratin, the building blocks of the tough and fibrous protein in skin (Fu-Chan et al., 2005; Kanitakis, 2002). Keratinocytes proliferate in the basal layer of the epidermis and gradually change its morphology as they move up to the final layer of the skin giving protection from foreign substances from entering the body. The next type is melanocyte, a pigment synthesizing cell originating from the neural crest and are limited to the basal layer. Melanocyte is responsible for the production of pigment melanin (giving rise to skin color), which then transferred to keratinocytes. There two forms of melanin: eumelanin and pheomelanin. Pale-skinned people tend to produce more pheomelanin and dark-skinned people produce more eumelanin. If melanocyte cells give rise to color, Langerhans cells on the other hand are designed for skin defense. Langerhans recognize and ingest the antigens found in epidermal tissue while Merkel cells are slow adapting oval shaped cells that combine with nerve endings to create sensory receptors for touch.

![Anatomy of human skin layers](image)

Figure 3: An anatomy of human skin layers. The outer layer of skin, epidermis is made up from keratinocytes, melanocyte, Langerhans cells and Merkel cells while dermis made up of the fibrillar structural protein or known as collagen. The outermost layer of the skin is the thinnest layers among the layers with 0.01 cm, the thickness of dermis layer and hypodermis layer are 0.19 cm and 0.60 cm respectively (Yusoff and Jaafar, 2012).

The epidermis is further divided into five different layers as shown in Figure 4: Stratum corneum, Stratum lucidum, Stratum granulosum, Stratum spinosum and Stratum basale. The epidermis is constantly renewing its layer tissues, in which the basal cells go through the proliferation cycles to balance loss of the cells from the outer surface of the stratum corneum (skin peeling or desquamation). The actual nature of this cycle may be different from one person to another and hence is important to be considered in optimizing the use of skin products in the long run. The keratinocytes start to differentiate while leaving the basal layer and they undergo a number of changes in structure and composition during the transition through stratum spinosum and stratum granulosum. During the keratinocytes maturation, the keratinocytes synthesize and express several different structures of lipids and proteins. The last cycle of keratinocyte
differentiation has changed their structure and transformed into corneocytes that is the outermost skin layer that people see and touch (Haake et al., 2001; Yusoff and Jaafar, 2012).

![Epidermis Layers](image)

Figure 4: Details of epidermis layers’ structure. Each of the epidermis layer undergoes renewing layer continuously starting from the stratum basale towards the stratum corneum. As it gets deeper through the epidermis layer, the younger the cells are.

### 3.1.1 Skin Turnover Time

Skin turnover time is the interest of the authors in anticipation of its influence on the management of treatment for skin disorders. It is commonly stated that the normal skin epidermis requires 27-28 days to renew its layers but other clinical studies on the cycle period for skin turnover reported differently as summarized in Table 1 (Epstein & Maibach, 1965; Grove & Kligman, 1983; Halprin, 1972; Pinkus, 1952). In skin turnover, there are two types of time measurement that can be considered namely the transit time and renew time. Transit time represents the time required for a basal cell to reach the granular layer while renewal time is an average time for all basal cells to reach stratum corneum layer. Transit time and can be equal to renew time if all cells move at the same rate but this does not normally happen in human epidermis.

<table>
<thead>
<tr>
<th>Publication</th>
<th>Skin turnover time</th>
</tr>
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<tbody>
<tr>
<td>Pinkus, 1952</td>
<td>Turnover time of 26.7 days, when mitotic duration of 1 h</td>
</tr>
<tr>
<td>Epstein &amp; Maibach, 1965</td>
<td>Average renewal time of human epidermal cells (basal, prickle and granular layers) - 13 to 18 days</td>
</tr>
<tr>
<td>Halprin, 1972</td>
<td>Malpighian layers (innermost layer of epidermis) transit time- 14 days</td>
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<tr>
<td></td>
<td>Total epidermal turnover time for normal skin- 52 to 75 days</td>
</tr>
<tr>
<td>Grove &amp; Kligma, 1983</td>
<td>Stratum Corneum transit time for young adults- 20 days</td>
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<tr>
<td></td>
<td>Stratum Corneum transit time for older adults- more than 30 days</td>
</tr>
</tbody>
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There are other important functions of stratum corneum besides protecting the skin against the environmental exposure and foreign substance invasion. Stratum corneum also helps to hydrate and retain water, thus prevents cracking (Murphrey and Zito, 2019). It has two function system components: (1) corneocytes as outputs of keratinocyte differentiation and (2) extracellular lipid matrix. The corneocytes protect mitotically active cells from the exposure of ultraviolet (UV), providing mechanical protection and control cytokine-mediated inflammation trigger (Menon, Cleary, & Lane, 2012). Ceramides, cholesterol and free fatty acids are important components of the extracellular lipid matrix that creates the stratum corneum’s brick and mortar organization controls permeability, enables selective chemical absorption and excludes toxins from antimicrobial peptide activity (Rawlings and Harding, 2004). Stratum corneum is continuously being replaced for repairing damage from wear and tear. On the other perspective, cyclic friction or pressure on stratum corneum has been found to stimulate callus formation which can be unpleasant to see and feel (Freeman, 2002).

3.2 Dermis

Dermis is the middle layer of human skin sandwiched between epidermis and hypodermis. Dermis lies on the subcutaneous tissue in hypodermis that houses lipocytes which are small lobes of fat cells. There are two main layers in dermis called papillary region, adjacent to epidermis, and reticular dermis, next to hypodermis. The main constituents in dermis are collagen, elastic fibers, and extracellular matrix. The supporting matrix is the basis of the dermis where protein and polysaccharides are bonded together to produce macromolecules, responsible for retaining water capacity of skin. The collagen forms the major constituent and has great tensile strength of the dermis while elastin makes up only a small section of the bulk (Mcgrath et al., n.d.). In a nutshell, dermis plays important roles in providing mechanical support and nourishment to human skin.

The importance of collagen and elastin was studied by Daly in 1982 where skin elastic behaviour and the structure of collagen and elastin fiber networks of the dermis were tested using tensile test method on human skin specimens (Daly, 1982). From the study, it was concluded that human skin samples (taken from the abdomen area) had exhibited elastic behavior. Initially, there was a large extension recorded even with a lower stress applied. Beyond the initial extension, when the skin sample had become stiffer, the change was comparatively small even with much larger applied stress. It was believed that the observed behavior was in response to the high stiffness of the collagen as the fibers becoming oriented and straightened out due to the applied stress. The Young’s modulus E for the skin sample was also computed and the values obtained were two orders of magnitude less compared to soft rubber or elastin were obtained.

A study of viscoelastic properties of human skin by Silver et al. (Silver et al., 2001) in 2001 used stress-strain curves from Dunn and Silver (Dunn and Silver, 1983) to obtain the elastic spring constant of collagen and elastin by converting the stress into true stress from engineering stress and a new stress-strain graph was then re-plotted (see Figure 5). The study suggests that the elastic spring constant for collagen and elastin is around 4.4 GPa and 4.0 MPa respectively. The differences in the collagen and elastin present in skin may influence the self-assembly of collagen and the resulting viscoelastic properties. All these properties of skin are expected to have some bearings on skin disorders discussed in Section 4.0.
4.0 COMMON SKIN DISORDERS

With prior knowledge of skin anatomy presented in Section 3, discussion of skin disorders in this section makes more sense. Skin disorders are related to the dysfunction of skin components or the layer's defect of human skin which can manifest as irritation and itchiness in some cases. Specific defects in enzymes, structural proteins or lipid metabolism have been identified as the root cause of skin disorders for most of the cases. There are also stratum corneum defects which may lead to protein or lipid abnormalities of barrier function defect, which in turn may lead to an increasing transepidermal water loss (Murphrey and Zito, 2019; Rawlings and Harding, 2004). This unwanted condition eventually affects the integrity of skin.

On an outward perspective, skin diseases can be categorized into three: Dry Skin (Eczema, Xerosis, Atopic Dermatitis and Psoriasis), Hyperpigmentation (Post-Inflammatory, Vitiligo and Melasma) and Acne. In a recent epidemiological study of skin diseases conducted in Himatnagar, Shah and Sheth (2019) found important statistics of skin diseases suffered among patients they studied. Based on Figure 6, the top three skin diseases are Eczema, Xerosis, and Acne with a specific percentage of 32%, 21%, and 16% respectively. The three combined makes up almost two third (79%) of the total percentage. The next group is made of Atopic Dermatitis (10%) and Post-Inflammatory (9%). The third group, having 5% or less, consists of Melasma (5%) and Vitiligo (4%) and Psoriasis (3%).
Figure 6: The statistics of a recent study in Himatnagar for the year 2019 is shown (Shah & Sheth, 2019).

The profile of research focus on three main categories of skin disorders has been produced using Science Direct Searched Engine (Figure 7) in order to understand not only the direction of interests among researchers but also to appreciate the weight of the problems specific to the skin categories. This trend is based on keywords search namely common skin disorders of dry skin, acne skin and hyperpigmented skin. In Figure 7, the graph correlates the total number of research papers on each of the category over a period from 1999 to 2019. Based on Figure 6, the trend of publications related to Acne and Hyperpigmented has remained almost the same over the period. However, in the case of dry skin, the trend is distinctive and overall, it is by far the most researched about compared to the other two. On a closer look, there has been a pronounced increment in the number of publications after 2011 which is signified by the slope of the trend. Noticeably, in 2019 there is a tremendous increase for dry skin with 884 publications as compared to 716 papers in 2018. Overall, from 1999, there has been a big gap between the number of publications for dry skin as compared to those of acne skin and hyperpigmented skin. This trend can be explained by the profiling of the prevalence chart of Figure 5 where majority of the population suffered from dry skin problem.
There are important factors that lead to human skin disorders such as environment, weather, hormones and genes. All the factors may differ on individual basis. For an instance, atopic dermatitis patience might have a historical family of atopic while some of psoriasis patience are affected because of the faulty in the immune system that makes skin cells turn over rapidly. However, this aspect of skin disorder is not addressed in this paper. Instead, the subsequent discussions detail out important aspects of the three categories of skin disorder plotted in Figure 6 in the order of the highest to the least publication interest.

4.1 Dry Skin

Dry skin can be recognized by the physical characteristics such as being rough and finely scaled (Uehara and Miyauchi, 1984). Dry skin is a condition often associated with a lack of natural oils or sebum. Some studies have suggested that microorganisms and chemicals exposure, low humidity and low environmental temperature are the factors that influence the patients to experience dry skin condition (Ashida et al., 2001; Uehara and Miyauchi, 1984). In another study, it was reported that sun exposure and excessive use of harsh soaps, cleansers and astringents could trigger the onset of dry skin disorder (Leveque et al., 1987). These are some of the important factors to consider in adopting an effective management of skin disorders tailored to specific individual needs.

Dry skin is found among children and adults and if it goes untreated, it can develop into abnormalities and eventually progress into skin diseases. Extremely dry skin refers to any skin condition that exceeds its normal dry state. Dryness is often associated with the observed impaired barrier function in atopic skin, psoriasis, ichthyosis, and contact dermatitis (Lodén, 2003). Dermatitis and eczema are frequently used terms to describe a polymorphic pattern of inflammation caused by dryness, atopic dermatitis, psoriasis and ichthyosis in the acute phase while xerosis and contact dermatitis is in the chronic stage. In a study conducted at Germany home care, the finding shows that more than half of the participants were affected by dry skin (Lichterfeld-kottner et al., 2018). In other study of atopic dermatitis among adult population in the USA, it was found that 60.1% of the participants had a mild disease while 28.9% and 11% of the participants suffered from moderate and severe disease respectively (Fuxench et al., 2018).

In addition, a questionnaire conducted by Larsen et al. in North Europe found that girls outnumbered boys in atopic dermatitis with a ratio of 1.3:1.0 (Larsen et al., 1996). The prevalence of ichthyosis vulgaris is estimated about 1 in 300 persons (Rabinowitz, 2015) while the prevalence of xerosis in elderly was 55.6% (Paul et al., 2011)

4.1.1 Morphology of Dry Skin

Dryness is frequently linked to damaged skin barrier function. The impaired barrier function triggers cytokine generation and secretion, which can lead to skin inflammation, increased proliferation of keratinocytes and epidermal hyperplasia (Lodén, 2003; Proksch et al., 1991). When this barrier function is impaired, the skin became dry, itchy, scaly and skin surface becomes rough compared to a normal skin as shown in Figure 8(a) and Figure 8(b). Skin surface of dry skin disorders can differ depends on its severity. Uehara and Miyauchi observed the skin surface between two types of patients; atopic dermatitis alone and atopic dermatitis with ichthyosis vulgaris. It is shown in Figure 9(a) and Figure 9(b) the severity of patient with atopic dermatitis alone and the patient who suffer from both atopic dermatitis and ichthyosis vulgaris. It can be seen that patient with atopic dermatitis and ichthyosis vulgaris tend to have more rough skin surface and scaly than the patient with only atopic dermatitis disorders.
The skin surface of normal and dry skin subjects. (a) Normal skin surface, no obvious wrinkles and smooth skin surface; (b) Dry skin surface with visible wrinkles and rough skin surface (Sato et al., 2000).

Figure 8: The skin surface of normal and dry skin subjects. (a) Normal skin surface, no obvious wrinkles and smooth skin surface; (b) Dry skin surface with visible wrinkles and rough skin surface (Sato et al., 2000).

Figure 9: Skin surface of dry skin patient. (a) with atopic dermatitis alone; (b) with atopic dermatitis and ichthyosis vulgaris (Uehara & Miyauchi, 1984).

The rate of substance penetration into skin to remain soft and smooth is related to the thickness of the stratum corneum of dry skin. It has been observed that dry skin has thicker stratum corneum layer compared to the normal skin and the tortuous lipid pathway around the corneocytes tend to have a longer penetration distance than the actual stratum corneum layer thickness (Potts and Francoeur, 1991). Leveque et. al. revealed that skin conductance and skin extensibility decreased with the severity of skin dryness may cause the stratum corneum to become thicker or drier (Leveque et al., 1987). A study by Saint-Leger et al. shows that xerosis does not change the total amount of stratum corneum but an increased proportion of free fatty acids and decreased amounts of neutral lipids are related to the level of severity of dryness (Saint-Leger et al., 1989). Xerosis is often associate with less stretchable stratum corneum due to a slight increase in epidermopoiesis.

Transepidermal Water Loss (TEWL) is the amount of water that evaporates through skin to the environment. An experiment conducted by Leveque et al. showed that it is normal for TEWL
to occur in dry skin due to the thickening of skin’s outer layer (hyperkeratosis) as a way for stratum corneum to compensate for a barrier function defect, suggesting an epidermis failure to produce a normal thickness competent barrier (Leveque et al., 1987). An increase in TEWL indicates a disturbance in the structure of the stratum corneum whereby it becomes more brittle and less stretchable with increasing dryness. The size of exfoliated corneocytes also decreases as the dryness increases.

4.1.2 Is Dry Skin Dehydrated?

Dry skin is commonly associated with dehydrated skin. Generally, dry skin and dehydrated skin are different; dry skin is more to skin type characterized by the lacking of natural oils or sebum while dehydrated skin is a condition signified by lacking of water (Kristeen Cherney, 2018). Shimizu et al. stated that dehydration is the result of a fluid imbalance and insufficient volume of circulation, either too little fluid consumption or too much fluid loss (Shimizu et al., 2012). In a similar study, Andrew Levitt et al. found that dehydrating condition affects the sweating and saliva production ability of the skin (Andrew et al., 1992).

In dry skin condition, the sebaceous glands of skin do not produce adequate natural oils needed by the skin, resulting in formation of white flakes, redness, scaly skin and irritation. For the case of dehydration condition, it can cause itchiness, dullness, sunken eyes and increased the appearance of wrinkles. In severe dehydration, symptoms like dizziness, dry mouth, fever and faintness can be present. An experiment on physical signs of dehydration in elderly people conducted by Shimizu et al. in 2012 found that dry mouth and fever were the most frequently observed signs in all of the patients with severe dehydrated skin and most of the patients showed lack of saliva production and decreased skin turgor.

Although dry skin and dehydrated skin are different, there are related on some grounds. In some cases, observed, dry skin conditions were characterized by lacking of both natural oils and water (De Rigal et al., 1993). For the suggested treatment, patients with dehydrated skin can be treated through diet and lifestyle by consuming more water to improve hydration. For patients with dry skin, they need to improve skin moisture through appropriate treatments such as frequent applications of suitable moisturizers. For patients with both dry and dehydrated skin, they can be treated by combining treatments for specific cases of dehydration and dry skins described earlier.

4.2 Acne Skin

Many people around the world suffer from acne and this is found among males and female at different age. Findings from different studies reported statistics that are significant in numbers. In 1998, the prevalence of US population that suffered from acne is 85% for aged 12 to 24, 8% for aged 25 to 34 and 3% for aged 35 to 44 years old (White, 1998). In the same year, an adolescent acne study conducted in Australia by Kilkenny shows that it was more common for girls than boys to have acne. They also found that the most common type of blemish was comedones (33%), followed by papules or pustules (29%), post inflammatory pigmentation (7%), acne scars (6%) and nodules (1%) (Kilkenny et al., 1998). In addition, a study found that acne continues to exist in about 64% and 43% of individuals in the 20s and 30s, respectively (Bhate and Williams, 2013). In a study based on clinical examinations, it was estimated that clinical acne lies in the range of 10% to 12% (Holzmann and Shakery, 2014). In a study involving students in Riyadh, it was found that 53.4% of respondents suffered from Acne Vulgaris (Al-Hoqail, 2003). In a more recent study in Kuwait, AlKhabbaz et al. clinically examined 714 patients and reported that 479 of them were
found to have Vulgaris (AlKhabbaz et al., 2019). They also concluded that females and overweight adolescents were more likely to have Acne Vulgaris.

On factors affecting acne, there are common causes found in literatures such as environmental exposure, hormone, stress and genetic (Adebamowo et al., 2005; Al-Hoqail, 2003). However, the relation between diet and acne are controversially discussed in some papers. Based on literatures, the cause-and-effect diagram for acne skin was created and presented in Figure 10 (Adebamowo et al., 2005; Al-Hoqail, 2003). In 2005, Adebamowo et al. had found that acne was positively related to milk especially skim milk as it was speculated that during manufacturing of skim milk, the bioavailability of comedogenic components might increase. Compared to whole milk, skim milk was found to have less estrogen, a hormone that may reduce acne (Adebamowo et al., 2005). Based on this study, it shows that diet selection has some bearings on promoting or reducing acne.

![Figure 10: Cause-and-effect or fishbone diagram of factors that worsen acne.](figure10.png)

Another diet related factor discussed in literatures is consumption of chocolate. In an early study entitled 'Effect of Chocolate on Acne Vulgaris' published by Minkin and Cohen in 1970, it was found that chocolate consumption did not affect the skin sebum condition of the 65 respondents. Thus, the study did not support a notion that chocolate stimulates sebaceous secretion and affect acne vulgaris (Minkin and Cohen, 1970). However, later in 2011, a published study by Block et al. was able to prove that chocolate could cause acne when the respondents of their study had shown significant changes in acne severity after a single chocolate consumption (Block et al., 2011). However, there are no solid proofs on the types of chocolate that are likely to cause acne. In another study, Cordain et al. investigated the dietary effects on acne vulgaris in rural and western areas (Cordain et al., 2002). In the findings, the incidence of acne in rural and non-industrialized areas was lower than that in Western populations. It is believed that the lower incidence of acne observed was attributed to the regular diet of mostly fish, fruits and coconut. In the study, rural areas were referred to Hawaii and the western areas other parts of USA.
4.2.1 Acne Formation and Types of Acne Lesions

This section describes acne formation and the types of acne lesions. Understanding this topic is the interest of the authors in managing acne for those affected. Acne is a chronic inflammatory disease of the pilosebaceous, cell-lined follicle with large sebaceous glands and a fine hair that seldom spreads out of the follicle (Reddy and Jain, 2019). The formation of acne undergoes four stages as illustrated in Figure 11: (1) inflammatory mediators released into the skin, (2) keratinisation alteration process leading to comedones, (3) increased sebum production under androgen control, and (4) bacterial colonisation of hair follicles on the face (commonly forehead, cheek, nose and chin), neck, chest and at the back for Propionibacterium acnes (Eichenfield and Leyden, 1991; Thiboutot et al., 2009; Williams et al., 2012).

![Figure 11: The process of acne formation on the skin. Sebum travels up hair follicles and out through pores onto the surface of skin. When skin produces extra sebum and dead skin cells, they can stick together and clogged pores resulting in skin blemishes. The bacteria that normally exists in small amount on the skin can grow in the sebum and causes clogged pores leading to inflammation (Pattillo, 2019).](image)

Skin needs sebum to remain healthy but too much of it can be detrimental to skin integrity. Sebum is an oily substance that is produced by sebaceous gland, which is connected to the hair follicles (Kuley, 1961). Propionibacterium acnes starts in the sebaceous follicle and is carried by sebum alongside dead cells and bacteria to the skin surface. The onset of acne later may develop into inflammatory pustules, papules and nodules (Johnson and Cummins, 1972; Reddy and Jain, 2019). Inflammatory skin can be characterized by pus, swelling and redness. Therefore, it is critical to regulate sebum in skin in order to control acne effectively. For treatment, some studies found that vitamin D could increase the regulation of sebum production and oxidized lipids can stimulate keratinocyte proliferation (Johnson & Cummins, 1972; KULEY, 1961).

Acne lesions come in different forms which include whitehead, blackhead, nodules, papules and pustules as illustrated in Figure 12. Whiteheads are closed pores packed with sebaceous gland secretion that swell under the tissue while blackhead is the opening pore that get plugged with a mixture of keratin and sebum, resulting in the darkened surface on the skin. Nodules are
solid lesions that tend to extend into deeper layers of the skin and cause tissue damage. It is very painful acne lesions and is likely to leave scars on the skin. Papules are solid inflammatory acne lesion without pus while pustules are small swollen acne filled with pus. Pus is the combination of dead skin cells, bacteria, leukocytes that formed around hair follicles. Different level of severity of acne skin is shown in Figure 13, where the most severe acne skins are shown to suffer from inflammation lesions of comedones, papules, pustules and some nodulocystic lesions.

Figure 12: Types of lesions on skin. It can be seen that bacteria involve in the formation of whitehead, blackhead, papule and pustule (Thomas, 2019).

Figure 13: Severity level diagram for acne skin. The quantities of non-inflammatory and inflammatory lesions on skin indicate the severity of acne skin. The acne becomes severe if the quantities of inflammatory increases on the skin (Do, 2018).

4.2.2 Adolescent Acne Vs Postadolescent Acne
As mention earlier, acne can happen to adolescents and adults and it is quite different from each individual. Usually, acne of teenage boys tend to disappear by the age of 20 to 25 years old
while girls or woman might experience acne into adulthood till past 40 years old (Capitanio et al., 2010). Acne can be categorized into two; (a) 'Persiste nt acne' is a continuation of the acne from adolescence into adulthood and (b) 'Late-onset acne' first presents after puberty, usually between 21 and 25 years of age.

In a study by Holzmann and Shakery on postadolescent, the results showed that 20% of the subjects suffer from late-onset acne after the age of 18 years (Holzmann and Shakery, 2014). Based on the study in 2012 by Khunger and Kumar, the prevalence of persistent acne was observed to be 73.2%, while late onset acne was 26.8% (Khunger and Kumar, 2012). Comparably, the inflammatory lesions of postadolescent are within U-zone (chin, jawline and neck), while noninflammatory and inflammatory lesions of adolescent acne lies on T-zone area (forehead, nose and cheeks). Postadolescent remains mild to moderate acne condition but adolescent acne can become severe (Choi et al., 2011). In another study, it was found that the cases of increasing pore diameter of late-onset acne and the higher sebum secretion among adult women with persistent acne might also be higher compared to cases among those without acne (C. Williams and Layton, 2006).

4.3 Hyperpigmented Skin

Pigment skin disorders can be defined as the loss or reduction of skin color. Sun protection, inflammation and other processes are involved in the pigmented skin. Pigmentation is related to melanin production inability or inability to transport melanosomes correctly. It is not only affected by keratinocytes but also by mast cells, Langerhans cells and lymphocytes. There are three major classifications of pigmented skin: depigmentation, hypopigmentation and hyperpigmentation as shown in Figure 14. Depigmentation is a complete pigment reduction while hypopigmentation is an unusually low amount of melanin. In this paper, the focus is more on hyperpigmentation, as it is more common cases compared to depigmentation and hypopigmentation.

![Figure 14: Classification of pigmented disorders: Albanism and vitiligo are two most common pigmented disorders in the Hypopigmentation group while in the Hyperpigmentation, PIH or acne scarring and melasma are usually the case.](image-url)
Hyperpigmentation is a harmless skin condition in which certain areas of skin become darker in color compared to actual skin color and this is caused by abnormally high amount of melanin. Hyperpigmentation is very common skin condition among skin of color including African Americans, Native Americans, Latinos, Middle Eastern and Asians. This was confirmed by a recent study; it was found that the most common hyperpigmentation cases were among African with 73.3%, followed by Indian 21.8%, white 2.6% and mixed race 2.3% (Dlova et al., 2019). Majority of the hyperpigmentation cases were observed among female with 75.8%. A survey study, conducted by Alexis et al. on 1412 patients who had visited Skin of Color Center from August 2004 to July 2005, found that Dyschromia or Pigmented Disorders is the second most diagnosed after acne in black patients and none in white patients (Alexis et al., 2007). In another study, Ogunbiyi et al. estimated the frequency of Nigerian pigmentation skin disorders was 8.6% (Ogunbiyi et al., 2004).

The melanosomes size and distribution patterns of melanosomes differ according to races. In 1969, Szabo et al. were the first researchers to investigate different distribution patterns of melanosomes in keratinocytes among different races (Szabo et al., 1969). He observed that the melanosomes were packed into membrane-delimited compounds called melanosome complexes in the skin of whites who were American Indian and mongoloids. In blacks and Australian aborigines, they were distributed singly within the epidermal cell cytoplasm. Szabo et al. also found that black melanosomes tend to be larger and wider in comparison to those of other races. Honda et al. also supported these findings in which the black melanosomes were found larger than those of whites according to the conducted experiments (Honda, Takamatsu, & Wei, 1972).

The melanosomes size and distribution patterns of melanosomes were examined in 14 whites from different ethnic groups using electron microscopic by Konrad and Wolff. They reported that there was a remarkable propensity for small melanosomes to be complex and for large melanosomes to be distributed as single melanosomes; it was apparent that there is a direct relationship between melanosomes size and distribution (Konrad & Wolff, 1973). It was also reported that melanosomes of the dark-skinned individuals are larger, elongated and more numerous resulting in disrupted degradation in keratinocytes and consequently in increased visible pigmentation (Costin and Hearing, 2007; Schiaffino, 2010).

4.3.1 Post-Inflammatory Hyperpigmentation

Post-Inflammatory Hyperpigmentation-ion (PIH) is a common hyperpigmentation recognized by the darkening of certain areas of the skin (see Figure 15) that occurs after an inflammatory dermatoses or cutaneous injury and tends to affect dark-skinned patients with greater severity. Nieuweboer revealed that the spots could be worst if the skin is exposed to the sunlight, chemical and some medication consumption (Nieuweboer-Krobopta, 2013). Lacz et al. presented two classifications of PIH namely epidermal and dermal pigmentation (Lacz et al., 2004). In most cases, epidermal pigmentation is brown and fades out in a few months while dermal pigmentation has a gray-brown color and is usually persistent.
Figure 15: Post-inflammatory hyperpigmentation caused by acne inflammation. The area of skin affected by acne wounds became darker and pigmented (Davis & Callender, 2010).

There is a wide range of PIH aetiological factors, including infections such as dermatophytosis; allergic reactions such as contact dermatitis; those from insect bites; papulosquamous diseases such as psoriasis; and skin damage from irritants or burn. Nevertheless, acne vulgaris, atopic dermatitis and impetigo are the most common causes of PIH in the colored skin (Davis and Callender, 2010). In one perspective, PIH is described as the outcome of melanocytes’ responses to cutaneous inflammation which can cause overproduction of melanin or an irregular dispersion of pigment (Grimes, 2009; Vashi and Kundu, 2013).

Previous studies suggested that PIH could occur both in the epidermis and dermis. When PIH is confined in the epidermis, there is an increase in the melanin production and transfer to keratinocytes. PIH within the dermis could result in damaged basement membrane, allowing melanin to enter the dermis, where it is phagocytosed by dermal macrophages or melanophages. Furthermore, melanophages can also migrate to epidermis and then return to dermis (Davis and Callender, 2010; Masu and Seiji, 1983). With such a complexity, designing an effective management of skin disorders for individual needs is a big challenged.

4.3.2 Melasma

Melasma is another common occurrence that could affect the quality of life for those affected in terms of emotional state and confidence level. Melasma refers to irregular brown macules on skin that are exposed to the sun and is one of the most common causes of hyperpigmentation. The most common melasma forms on the face of certain pregnant women due to birth control pills consumption; usually the symmetrical hyperpigmented spots are most noticeable on the forehead, cheeks, upper lip, nose and chin as shown in Figure 16.
Although the exact cause of melasma is unclear, the pathogenesis of the disorder involves multiple factors. Exposure to UV radiation or visible light and genetic influences are two of the main factors of melasma. Other causes of melasma include use of oral contraceptives, pregnancy, estrogen progesterone therapy, anticonvulsants, thyroid dysfunction, medications and cosmetics. In a clinical study of melasma in 160 patients by Sardesai et al., it was found that increasing incidence of melasma in females could be attributed to hormonal effects such as during pregnancy with 32%; cosmetics such as whitening creams and all-purpose moisturizing creams with perfume with 10%; and the use of oral contraceptive pills with 8.5% (Sardesai et al., 2013).

Wood’s light examination of the skin can reveal the presence of melasma, which can be divided into three types namely epidermal, dermal, and mixed. In an article by Pandya and Guevara, the differences of all the types are presented in details (Pandya and Guevara, 2000). The epidermal type of hyperpigmented skin shows excessive quantities of melanin in the basal and supra-basal epidermis but a normal number of melanocytes. During Wood’s light examination, the borders of melasma spots are clearly demarcated. In the dermis type, the causes of melasma are related to melanin within the dermis, collagen bundles, or melanophages. However, the Wood’s light reveals no sharp lesion demarcations and this is likely due to the lesion color (brown-grey) of being harder to differentiate. Lastly, the mixed type of melasma is characterized by increasing melanin found in epidermis as well as melanophages in dermis. The Wood’s light examination shows the clinical aspect of both pigmentation types and they appear deep brown in color. Figure 17 shows
differences between two types of hyperpigmentation; post-inflammatory hyperpigmentation (PIH) and melasma.

Figure 17: Cases of hyperpigmentation: PIH on the cheek versus irregular brown macules of melasma on the forehead.

5.0 CONCLUSION

Skin disorder is a big concern and the three tops in the list are dryness, acne, and hyperpigmentation. Literature on dry skin problem have a growing interest especially in the last five years with a very sharp increase in publications over the years. There are a number of etiologies for dry and acne skin in patients such as environment exposure, genetic factors and hormone while exposure of chemical, sun and injury cause hyperpigmentation on skin. In addition, all these common skin disorders are related to each other; for instance, the acne skin effect is one of the causes of post-inflammatory hyperpigmentation. Extremely dry skin can cause acne too as sebum production is high in response to irritation tough the skin may be rough and scaly. Skin disorders are such burdens to most of people as it is not only painful but could lead to psychological impact and can be very costly to treat. In the long run, it could affect the quality of life. This review paper serves as a groundwork for a current research on skin tribology and the general interest is to provide more understanding on skin disorders. Better understanding can empower the public to make informed decisions on Why, What, and How in dealing with skin disorders and the choice of treatment and skin products that works for them. They know which parts of skin component are likely to become dysfunctional and the triggering factors of specific skin disorders. The triggering factors are important considerations in formulating and adopting effective management of skin disorders tailored to specific individual needs.
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