FEATURE ARTICLE

CE 1.5 Contact Hour

# Exposure to Dihydroxyacetone in Sunless Tanning Products

## *Understanding the Risks*

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**ABSTRACT:** The public has been warned for years about the dangers of ultraviolet exposure from natural sunlight and tanning beds due to the associated risk for skin cancer development. An alternative to obtaining the sun-kissed look without ultraviolet exposure has been self-tanning products, which are applied directly to the skin via lotions, sprays, foams, and wipes. However, recent research has indicated that the chemical dihydroxyacetone (DHA), which is the active agent in most sunless tanning lotions, may cause cell damage via free radical reactions. Changes in pigmented lesion appearance during dermoscopic examinations after use of products containing DHA have been documented, and these findings will be analyzed. This integrative research review will examine evidence-based research regarding the risks of using DHA-containing products. Nola Pender's health promotion model is recommended to identify strategies that healthcare providers can use when developing anticipatory guidance to address factors leading to barriers in health promoting behaviors. This model is focused on improvement of well-being while preventing diseases.

**Key words:** Cell Damage, Dihydroxyacetone, Dermoscopy, Free Radicals, Sunless Tanning

The public has been warned for years about the dangers of ultraviolet (UV) exposure from natural sunlight and tanning beds due to the increased risk of developing skin cancer. UV radiation has been shown to cause an increased incidence of melanoma, basal cell carcinoma, and squamous cell carcinoma in adults. Despite current initiatives to educate the public on skin cancer prevention, substantial numbers of people continue to believe that their appearance is improved with a tan (Martin et al., 2009). The desire for bronzed skin, albeit concerns of skin cancer development, has led many to opt for sunless tanning products to achieve a bronzed appearance. However, recent evidence has suggested that one of the main active ingredients in sunless tanning products, called dihydroxyacetone (DHA), may have more adverse effects to consumers' health than previously understood. This integrative review of literature will examine recent research in regard to the use of DHA in tanning products. It will present evidence that suggests that there is no clear, safe exposure of mucous membranes to DHA during inhalation of tanning spray application, which may pose unknown health risks; that DHA makes the skin more susceptible to UV damage; and that DHA can cause alterations in the appearance of skin during dermoscopic examinations, leading to unnecessary biopsies and the possibility of misdiagnoses.

## OBJECTIVE

The purpose of this integrative review was to determine if there is plausible evidence to suggest that the use of sunless tanning products containing DHA contributes to disease development via systemic absorption in adults. The goals of this review were to improve current educational and anticipatory guidance to patients related to this topic, to ameliorate overall health and well-being by guiding nursing practice with evidence-based research, and to identify implications for further research.

## METHODOLOGY

This integrative research review will examine studies related to the safety of DHA when introduced beyond the stratum corneum and the effects DHA has on dermoscopy findings so appropriate anticipatory guidance can be developed for clients. Evidence-based qualitative and quantitative studies and systematic reviews accessed through databases

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including CINAHL, PubMed, MEDLINE, and one academic Web search engine (Google Scholar) were reviewed. Most of the studies referenced for this review were published within the last 5 years to utilize the most current research available. Nola Pender's health promotion model is used to guide suggestions for the development of anticipatory guidance to change unhealthy behaviors and promote skin health. This model is directed at increasing the patient's level of well-being and acknowledges the importance of the ability of the nurse to motivate change by modification of behavior-specific knowledge variables.

## BACKGROUND AND SIGNIFICANCE

Before the 20th century, pale skin was associated with high social class, wealth, and beauty. People would go through tremendous efforts to keep skin light and blemish free. Skin bleaching products were often used to achieve a pale appearance. In 1928, the number of articles and advertisements in women's fashion magazines promoting tanned skin dramatically increased (Martin et al., 2009). Tanned skin became associated with wealth and an improved sense of self-image soon after the launch of these advertisements. The incidence of melanoma has grown more rapidly than any other cancer since tanned skin became more desirable (O'Leary, Diehl, & Levins, 2014).

In the 1950s, Dr. Eva Wittgenstein from the University of Cincinnati started to research DHA and its ability to produce tanned skin. Her research was prompted from the brown coloring that was left on the skin of children who were treated orally with DHA for glycogen storage disease, which they often spat out, and the product landed on their skin causing dark spotting. It was not long before sunless tanning lotion was introduced to the public in the 1960s. Since its public introduction, many people have opted to use this as an alternative to natural sunlight or tanning beds to achieve their bronzed skin. For many years, self-tanning products have been considered a safe alternative to UVA or UVB exposure.

Self-tanning products can now be applied topically by hand, sprayed on at home, airbrushed by a technician, or sprayed in a tanning booth with misters. DHA has been approved by the U.S. Food and Drug Administration (FDA) for external application in cosmetic products since 1977 with a concentration of up to 15%. The FDA indicates that DHA should not be inhaled, ingested, or used in such a way that the eyes, eye area, nose, or mouth is exposed to it because the risks, if any, are unknown (FDA, 2016).

## LITERATURE REVIEW

### *Mechanism of DHA Action*

DHA, also known as glycerone or dihydroxy-2-propanone, is a three-carbon sugar ($C_3H_6O_3$), which is often derived from plant sources. The National Center for Biotechnology Information (2016) published a compound summary of DHA. This summary included information regarding the chemical and physical properties, pharmacology and biochemistry, use and manufacturing, toxicity, safety and hazards, and biological test results of DHA. The toxicity information included in this report noted that cells that were treated with DHA showed dose- and time-dependent changes that included cytoplasmic budding, chromatin condensation, and cell detachment. There was a significant decrease in cell proliferation after 24 hours of DHA exposure. After exposure to a 5% DHA solution for 21 days, epidermal thickening and dermatitis of the skin were noted in laboratory animals. After 42 days of treatment with the same solution, hyperplastic and dyskeratotic changes and moderate inflammatory reactions were seen.

Long-lasting topical tanning products contain the sugars DHA or erythrulose, which cause a "Maillard reaction" when contacting proteins in the outer layers of the stratum corneum and epidermis (O'Leary et al., 2014). This reaction happens when free amino acids from skin proteins combine with DHA in the stratum corneum. This combination creates the tanned appearance of skin. Results are generally seen within a few hours of application. UV light exposure is not needed to initiate this chemical reaction.

### *Adverse Effects of DHA on Cells*

Jung, Seifert, Herrling, and Fuhs (2008) researched the role of self-tanners in the induction of free radicals in the skin. Researchers could quantitatively determine the free radical induction effects using the radical sun factor method. During the Maillard reaction, sugars in DHA react with keratinocyte proteins causing oxidation of the sugar derivatives. This oxidation caused chain reactions, which led to free radical injury to the skin. This is the process used to create the tanned appearance in skin. DNA glycation is a process of reducing sugars that can damage nucleic acids. Advanced glycation end products (AGEs) are also known as glycotoxins. These are formed via the Maillard reaction. AGEs of DNA are spontaneously formed by the reaction of carbonyl compounds such as DHA. Excessive amounts of AGEs in body tissues or circulation can become pathogenic causing oxidative stress and inflammation, which can alter the structure and function of proteins (Uribarri et al., 2010). AGEs have been associated with the development of chronic degenerative disorders such as Alzheimer's disease, cardiovascular disease, and diabetes. An investigation of the effects of DHA on cell survival and proliferation indicated that DHA caused DNA damage as revealed by alkaline comet assay (National Institutes of Health, 2016).

An Amadori product is an intermediate in the production of AGEs described previously. The enolization processes of these Amadori products and their oxidation products are known to produce free radicals contributing to the formation of oxygen-derived free radicals and their subsequent oxidative damage to proteins (Jung et al., 2008). Free radicals are oxygen-containing molecules with unpaired electrons that can interact with cell components

such as DNA, proteins, or lipids, which can destabilize the cell causing oxidative stress. This can cause breaks in DNA strands. Topical DHA levels of 5% or greater increase susceptibility to free radical damage from sunlight for 24 hours after application (Garone, Howard, & Fabrikant, 2015).

The materials used for the Jung et al. study included skin biopsy samples from pigs and DHA purchased from Sigma-Aldrich, Germany, and liposomal encapsulated DHA from ROVI Cosmetics International, Germany, with concentrations of 5%, 10%, and 20% prepared in distilled water and used for experimentations within 12 hours (Jung et al., 2008). The methods used to obtain evidence of free radical formation included use of a sun simulator with UVA and UVB; an X-band electron spin resonance spectrometer, Miniscope MS200; and a nitroxyl spin probe (PCA). The restoring force surface method was applied to DHA dissolved in water and DHA encapsulated in liposomes. Results showed free radical formation in all samples and that irradiation caused increased free radical injury, with a higher concentration of tanning agent causing higher radical induction. Conclusions from this study indicate that DHA has a detrimental effect when exposed to UVA and UVB; however, encapsulation of DHA in liposomes can reduce this effect. Use of a potent antioxidant can also minimize additional generation of free radicals when applied simultaneously with DHA during UV exposure.

### DHA Use and Effects Beyond the Stratum Corneum

Garone et al. (2015) discussed the FDA's concerns in regard to use of DHA in aerosol spray form. There is limited, current research available as to the effects of DHA on levels of the skin deeper than the stratum corneum or on mucous membranes. The FDA has postulated that 11% of the DHA that is applied to the skin reaches living cells in the epidermis and dermis (Garone et al., 2015). The FDA has not approved the use of DHA-containing products applied via aerosols because of possible exposure to areas such as eyes, soft tissue below the eyes, lips, or mucous membranes or internally through nose and mouth. Some physicians have expressed concern about chronic spray tan use increasing the risk of pulmonary diseases such as chronic obstructive pulmonary disease and asthma as well as cancer (Garone et al., 2015).

Documented side effects of spray tans containing DHA include rashes, cough, dizziness, and fainting. Fragrances and preservatives can be added to self-tanners during spray application, which may contain parabens that have been linked to rosacea and allergic contact dermatitis (Garone et al., 2015). A controlled study on the effects of prolonged use of DHA-containing tanning products on Mexican hairless dogs revealed that frequent, widespread treatment with a 5% DHA solution over 42 days led to severe contact dermatitis, which was associated with a damaged stratum corneum (Kimura, 2009).

In some of the cases of dermatitis seen in the previously stated research study, necrosis was seen within the epidermis as well as blister formation under a parakeratotic corneum. Parakeratosis is a normal finding in mucous membranes. However, when seen in the skin layer, it is indicative of nuclei that are retained in the stratum corneum as well as thinning or loss of the granular layer. This is generally seen in neoplastic or inflammatory diseases where there is a high cell turnover.

A case study in 2013 offered a new insight into postoperative skin damage in a 34-year-old patient who received spray tan treatment before surgery. After the patient's surgical procedure, robotic-assisted lysis of adhesions, vaporization of endometriosis, and a myomectomy, surgeons noted erythema and disruption of the deep dermal skin layer where adhesive tape was applied (Krause, Bohler, & Nakajima, 2013). After consultation with a wound care specialist, it was determined that the patient had experienced an interaction from the chemicals in the sunless tanning product, the presurgical antiseptic solutions, and the adhesive tape that were used. In conclusion, authors advised providers to be aware that sunless tanning chemicals may cause interactions with the surgical products previously stated, and patients should be advised to avoid the use of sunless tanning products before surgery.

### Effects of DHA Products on Dermoscopy Findings

Dermoscopy has led to great improvements in the detection of skin cancer, especially malignant melanoma. The effects of sunless tanning on dermoscopy findings of pigmented skin lesions were reviewed in a recent study (Gyllencreutz, Bostrom, & Terstappen, 2012). This pilot study reviewed tanning agents that specifically contained DHA. Researchers hypothesized that the use of tanning agents before having a dermoscopic examination would alter the appearance of lesions and lead to misdiagnosis. Seven patients with 25 pigmented lesions were separately evaluated by two dermatologists. Dermatologists used an algorithm that consisted of Menzies method for nevi on the body, then scored them as benign, dysplastic, malignant, or equivocal, and made determinations for follow-up, biopsy, or excision (Gyllencreutz et al., 2012). The results of the evaluation of body lesions after use of DHA-containing products were equivocal for some, and none were considered malignant or dysplastic. Flat nevi presented with dots in half of the photos and elevated nevi showed blotches and globules in all the follow-up photos. This led to recommendations for follow-up but no biopsy or excision. The features in the facial lesions were more equivocal than those of the body. Follicular pigmentation was seen more often, which slightly mimicked lentigo maligna (LM) and lentigo maligna melanoma (LMM), which led dermatologists to recommended biopsies for all equivocal results (Gyllencreutz et al., 2012). The decision to biopsy based on the changes in lesion patterns with use of DHA would be supported by a recent study,

which suggests that follicular pigmentation is a common feature in LM/LMM (Pralong et al., 2012). This study concluded that tanning products containing DHA altered the appearance of facial pigmented skin lesions that resembled LM, which may lead to an increased risk of unnecessary biopsies or excisions in the seven patients who participated. The study was unable to show that the use of DHA made skin lesions appear malignant or dysplastic, and a larger study with more investigators using a mix of benign and malignant lesions may improve data (Gyllencreutz et al., 2012).

Skin changes can be seen via dermoscopic examinations for several months after product use and have been most notable in raised lesions, thickened epidermis, and stratum corneum. Changes such as hyperkeratosis can be seen in the form of large horn pseudocysts and large amounts of pigment in the overlying horny layer indicating a possible reaction to DHA, such as that seen in a recent clinical case study of a 39-year-old woman who used a DHA-containing airbrush tanning product 20 days before dermoscopic examination (Martin, Monteagudo, Calduch, Villalon, & Jorda, 2007).

### Review of Delivery Systems and Toxicology

Hoglund, Mogensen, Bossi, and Glasius (2006), from the Danish Toxicology Centre and the National Environmental Research Institute in Denmark, reviewed the levels of exposure to DHA in spray application by evaluating the delivery systems used for spray tanning. Three different application techniques were discussed, including turbine spray, closed booths (second generation), and open booths (third generation). The method used for this research included measurements of DHA in aerosol droplets < 12 μm in diameter in the booths and manual turbine sprayers as well as in rooms adjacent to the tanning booths. The findings revealed that the highest level of exposure to DHA was delivered by the modern, closed-booth machine.

Researchers reviewed DHA concerns with representatives from some of the large manufacturers of tanning booths; none of which could document that DHA was safe (Hoglund et al., 2006). The major manufacturer Magic T completed studies regarding the effects of DHA when inhaled, as well as its effects on eyes and mucous membranes, but would not release findings to researchers (Hoglund et al., 2006).

Preparation recommendations, spray treatment, and manufacturer's safety instructions were also reviewed. Hoglund et al. (2006) discovered that customers were advised by operators to avoid inhaling the mist and close eyes and mouth during application of the product. Manufacturers of the fourth-generation machine advised the use of disposable underwear, nose filters, and eye protection. The FDA indicates that customers should ask for these protective devices before having tanning mist applied.

Studies have been completed regarding the safety of DHA since 1960, yet there is limited research regarding the possible toxic effects of DHA, and much of it is conflicting. Several studies including human and animal research had indicated no toxic side effects with exposure to skin and mucous membranes in rabbits and ingestion by humans and rats. An in vitro study referenced in the Hoglund et al. (2006) report indicated that DHA may be genotoxic with mutagenic properties, which has led to further questions regarding the safety of this chemical. Evidence has shown that DHA causes DNA damage in cultured keratinocytes (Holman et al., 2013). Researchers noted that, although DHA is considered a nontoxic, noncarcinogenic chemical, the fund of knowledge about possible toxicity and mutagenicity is limited (Balogh et al., 2011).

### Contact Dermatitis and Spray Tans

Several ingredients are often added to self-tanning products containing DHA including perfumes, bronzers, moisturizers, erythrulose, preservatives, thickening agents, emulgators, and Vitamins A, E, and C. Several of these products have been indicated in allergic-type reactions causing dermatitis or difficulty breathing for consumers with respiratory conditions such as asthma. A case study published in 2015 documented a significant contact dermatitis in an otherwise healthy 49-year-old woman who used a spray tan containing DHA, which was preserved by methylisothiazolinone (MI) and methylchloroisothiazolinone (Madsen, Andersen, & Andersen, 2015). The patient had a known allergy to nickel and had a reaction to the spray tan on her face, neck, arms, and legs. Authors indicated concern about increases in allergic contact dermatitis cases related to use of MI, which is used as a preservative in spray tans and many other cosmetic products. Patch testing for this patient confirmed the reaction to this chemical.

Aerts et al. (2014) conducted a retrospective chart review to investigate the increase in MI allergy reports in Belgium. Researchers reviewed medical charts for 6,599 patients from January 2010 to December 2012, and 2,081 patients from 2013 were included (Aerts et al., 2014). Results indicated that mostly women were affected by MI, with rashes frequently located on the face and hands. The study recommendations included discontinuation of the use of MI used in leave-on cosmetic products, and safer concentrations should be used in rinse-off products (Aerts et al., 2014). Further research with a focus on cross-sectional reactions related to other isothiazolinone derivatives with different test conditions and other clinical manifestations such as respiratory reactions was recommended.

### Tanning Behaviors

Understanding why clients make the choice to seek methods to obtain tanned skin should be assessed to develop a successful method to deter this behavior. Regardless of the method used to tan skin, the outcome has meant that some form of skin damage or changes in the keratinocytes have occurred. An integrative review of literature com-

pleted by Holman et al. (2013) offers insight into strategies to reduce indoor tanning. Researchers reviewed the role of attitudes and behaviors toward tanning and the pressure put on people to have a pleasing physical appearance by having tanned skin. Social factors contributing to the behavior that lead to tanning should be recognized. The researchers note that inhalation of DHA-containing products cannot easily be avoided for people who use spray-on tanning booth methods and evidence is lacking whether DHA causes the same type of damage to humans as it has shown in cultured keratinocytes. People often believe that this method is a safe alternative to achieving tanned skin. Authors concluded that a multilevel transdisciplinary approach will be most effective to get through barriers that exist in reducing future indoor tanning use and skin cancer development. Providing patients with the proper education regarding the methods of how tanned skin is achieved, the damage it creates, and the possible risk for disease development is essential in promoting optimal health. These techniques can be considered to reduce the application of DHA-containing tanning products in spray techniques, but further study toward the applicability of these techniques should be considered to educate the public on the risks of DHA use. Public health successes in the reduction of tobacco use should be used to facilitate change regarding indoor tanning use (Holman et al., 2013).

The objective of an integrative review of literature by Buller et al. (2011) was to summarize estimates on sun burns, protective behaviors, and indoor tanning gathered from national and select statewide behavioral studies. The method for data collection was retrieval of information from national surveys in 1992, 2004–2005, and 2007–2009 from MEDLINE and PyschINFO along with reference lists and online surveys. Limitations of this study included potential recall errors in recall measures and lack of data on children. Researchers concluded that additional efforts need to be made to promote more protective behaviors especially in women and adolescents in the United States.

O'Leary et al. (2014) conducted a study pertaining to the risks of tanning and concluded that topical self-tanners are safe alternatives to UV tanning, but users should be cautious because exposure to UV light after application of self-tanning products can cause production of free radicals and they do not provide UVR protection. This review of literature notes that tanning behavior has become more high risk and skin cancer rates coincide with these findings. Researchers reviewed all methods of tanning skin, which included sun, indoor tanning, topical products, tanning pills, and melanocyte-stimulating hormone injectables, and concluded that there is no safe tan and physicians should provide guidance to their adolescent and young adult patients. They recommend appearance-focused interventions that show the outcomes of tanning skin. They also indicate that sunless tanning can be promoted along with the previously stated interventions to deter tanning behaviors. One important limitation of this study is that no information is included regarding the differentiation between application methods of sunless tanning products and the possible harmful implications of sunless tanning products with DHA being inhaled.

Several studies have suggested the use of self-tanning products as a safe alternative to reducing UV exposure, but few have addressed the correlation of behavior to skin tanning. A qualitative study recently aimed to identify if the use of sunless tanning products reduced UV exposure in those seeking a tan and if there were barriers to use (Paul, Paras, Harper, & Coppa, 2011). The sample consisted of 79 women ranging in age from 15 to 50 years in Australia. Participants were interviewed about the role of tanning, their views of sunless tanning products, their likelihood of use, and if use of these products would affect the amount of UV radiation they exposed themselves to. The findings of this study indicated that these women's perceptions of being tan aligned with improved self-esteem, body image, and social interaction. Those at a higher risk of skin cancer as identified by Fitzpatrick skin phototype I (fair skin, burn easily) seemed more agreeable to change sun behaviors as opposed to the rest of the participants who did not think that using sunless tanning products would curb their UV exposure. The limitations of this study were that the participants are not considered representative of the population as it was a convenience sampling, the participants' views were hypothetical, and all participants were active tan seekers (Paul et al., 2011).

## NOLA PENDER'S HEALTH PROMOTION MODEL AND ANTICIPATORY GUIDANCE

Nola Pender's health promotion model can be applied clinically to assess and design a plan of care for patients that can improve overall well-being, with the understanding that individuals actively seek to regulate their own behaviors. Per this model, to initiate behavioral change, a person must take the initiative to reconfigure the patterns of his or her interactions within his or her environment. Influences from the external environment can increase or decrease participation in health promoting behaviors. This is a relevant theoretical proposition that can be applied readily to identify ways to modify behavior regarding the desire for a tanned appearance. The media's role in promoting the bronzed look can greatly affect the opinions of youth and lead to poor decision-making related to sun exposure moving into adulthood. Millions of Americans continue to engage in high-risk sun behaviors despite warnings of the dangers of UV radiation (Hunt, 2011).

## IMPLICATIONS FOR FURTHER RESEARCH

Further research is needed to examine the safety of DHA as well as the possible long-term systemic effects that these products may have on the human body. Little research has been completed regarding the effects of DHA-containing products when inhaled into airways or introduced to mu-

cous membranes. Clear guidelines should be proposed in regard to the proper protective equipment needed to avoid exposure to DHA products if spray application continues to be available to the public. The use of these products in misting machines is not approved or regulated by any overseeing government body such as the FDA.

The type and location of damage in stages of cellular growth can lead to DNA injury, which may lead to mutations within the cell; this may in turn lead to cancer, cell death, or acceleration of the aging process (Hoejimakers, 2009). Further research should be considered to examine the potential benefits of topical antioxidants and liposome encapsulation to reduce the free radical damage seen with the use of DHA products. The development of cancer and the process of aging can be delayed by the avoidance of exogenous genotoxins, which will reduce DNA damage (Hoeijmakers, 2009).

If clinical changes are seen on dermoscopic examinations, clinicians should inquire about the use of DHA-containing products (Gyllencreutz et al., 2012). Patients should routinely be advised by healthcare providers to avoid using self-tanning products containing DHA before dermoscopic examinations to avoid skin changes that can mimic cancer. This would inevitably reduce unnecessary biopsies.

## IMPLICATION FOR PRACTICE

Healthcare providers can tailor treatment plans by using a holistic approach to review the motivation for which a person perceives benefits versus risks of behavior change, understanding that the individual seeks to regulate his or her own behavior. Nola Pender's health promotion model identifies several ways that nurses can act as the catalyst for motivation to change health behavior in patients. The health promotion model can be useful in areas such as tobacco cessation, skin cancer risk reduction, and weight management, where the goal is to prevent illness. This model has been useful in many different settings and supports a multidimensional approach.

Healthcare providers should continue to counsel patients on the risks of skin cancer development with exposure to UVA and UVB rays, both in natural sun and tanning booths. Recommendations for safe skin behavior should start in the adolescent patients. Tanned skin is still much desired, and dangerous behaviors related to tanning can start in this age group. Sun protection is relatively low with older adolescents and young adults (Buller et al., 2011).

Professionals who work in tanning salons are at an increased risk for inhalation when the proper exhaust equipment is not utilized. These employees should consider use of N95 respiratory masks for protection. The FDA recommends that protection including nose plugs, undergarments for protection of mucous membranes of the genitals, and eye protection be used during spray exposure. Hoglund et al. (2006) made the following recommendations regarding spray tan products:

> ***(a) Self-tanning products should not be inhaled or come into contact with mucous membranes; (b) People with asthma, sensitive skin and cuts and grazes should consult a doctor before treatment; (c) Keep the mouth closed and protect lips with lip salve during treatment; (d) Expectant and nursing mothers should not use self-tanning products in spray booths; (e) Regular weekly use over a long period is not recommended while knowledge about DHA is so limited; (f) Self-tanning products do not adequately protect against the sun's rays and therefore when exposed to the sun it is still important to follow advice and use sun cream; (g) booths should be equipped with extraction devices so that spray is not spread in the surrounding premises with resulting unnecessary exposure of personnel and customers. (p. 45)***

Patients should be advised that, although topically applied sunless tanning lotions have been deemed safe by the FDA, application in an aerosol form (such as those in spray tanning booths), where the product can encounter mucous membranes, has not been identified as a safe practice and is not regulated by the FDA. For patients who use sunless tanning products, they should be advised that this can change the appearance of lesions during dermatoscopic examinations. Patients should alert their dermatologic provider regarding use of such products as this may reduce the risk of unnecessary biopsies and change follow-up protocol. Those who use self-tanning products should limit time spent in the sun and use photo-protective equipment as self-tanning can induce UV-generated free radicals in the skin 24 hours after product application (O'Leary et al., 2014). If patients are scheduled for any type of surgical procedure, and it is known that they use sunless tanning products (regardless of mode of application), they should be advised to discontinue use of the product before their procedure as evidence has shown that possible reactions to topical products used postoperatively, such as adhesive tape, can occur.

Sunless tanning products can also contain preservatives such as MI, which have been implicated in increasing cases of dermatitis. Healthcare providers who have patients using these products should consider this as a source of skin irritation when devising their differentials. They should consider the use of the health promotion model when assessing and treating patients to gain a better understanding of why tanned skin is important to their patient and what role outside variables (such as society) have in their patient's health behavior. This can be important information in identifying potential barriers to health promotion.

## CONCLUSION

Findings of this integrative review indicate that there is no clear, safe use of DHA-containing sunless tanning prod-

ucts when applied via aerosol delivery systems. It is suggested that an overseeing government body, such as the FDA, should take charge of regulating the use and safety of equipment used to apply self-tanning products via aerosol. It has been posited that chemical reactions that occur during the Maillard reaction caused by DHA in sunless tanning products may cause DNA damage. Although there is a relative acceptance of these products when applied via lotion directly to the skin, the concern about DNA damage warrants further research. This research would assist in identifying if the DNA damage seen with the use of DHA in sunless tanning products can cause diseases in the human body. Increasing evidence suggests that DHA contained in sunless tanning products causes changes in pigmented lesions, which may cause healthcare providers to biopsy lesions based on appearance consistent with LM or LMM. ■

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