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Ultraviolet filter, fragrance and preservative allergens in New Zealand sunscreens

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ABSTRACT

Background/Objectives

Allergic contact dermatitis, photoallergic contact dermatitis and irritant reactions to sunscreens are common reasons for dermatology consultation. Patch testing for contact allergy relies on up-to-date knowledge of allergen exposures. The aim of this study was to investigate contact allergens and photoallergens in sunscreens commercially sold on the shelves of supermarkets and pharmacies in New Zealand.

Methods

A comprehensive market data review of suppliers' websites was performed from March to August 2019 to obtain a list of the commonly sold sunscreens in our region.

Ingredients were collated and analysed according to International Nomenclature of Cosmetic Ingredients (INCI) names. Ultraviolet (UV) filters, preservatives and fragrances were included for analysis. Place of sale and cost of sunscreens were also recorded.

Results

Ninety-five sunscreens were analysed: 36% sold in supermarkets, 43% in pharmacies and the remainder available in both. The most frequent UV filters were butyl methoxydibenzoylmethane (contained in 70% of products) followed by octocrylene (63%) and homosalate (50%). The common photoallergen benzophenone 3 was found in 19% of products. Phenoxyethanol was the most common preservative (68%) followed by disodium EDTA (30%) and propylparaben (26%). Two sunscreens contained methylisothiazolinone. Sixty-one per cent contained at least one fragrance, the most frequent being limonene (17%) and linalool (13%). There was an average of 1.1 New Zealand baseline series allergens per product (range 0 to 6, standard deviation 1.27).

Conclusion

Common allergens including those with high sensitising potential were frequently found in New Zealand sunscreen. Knowledge of ingredients used by manufacturers is useful in dermatological assessment of skin contact reactions.

INTRODUCTION

Over the years, there has been an increased public awareness of anti-carcinogenic and anti-photoageing effects of sunscreens, largely due to reinforcement by public health campaigns.¹ With the increasing use of sunscreens, there has been a rise in reports of adverse reactions including allergic contact dermatitis (ACD) and photoallergic contact dermatitis (PACD).^{2,3} A previous paper documented up to 19% of Australian adults has experienced a sunscreen reaction, of which approximately 10% were allergic in aetiology.⁴

Despite inactive ingredients such as fragrances, preservatives and vehicles being the most common contact allergens and photoallergens in sunscreens, chemical ultraviolet (UV) filters such as benzophenones have emerged as common causes of ACD and especially PACD.³⁻¹⁰ Furthermore, UV filters are frequently found in other products such as moisturisers and shampoos to prevent photodegradation and extend product shelf life.¹¹⁻¹³ This repeated exposure from multiple sources may increase the risk of sensitisation and subsequent ACD.¹⁴

An understanding of potential allergens and photoallergens in sunscreens currently sold in our local market is useful when assessing patients with skin reactions to sunscreens, particularly to plan and interpret results of patch and photopatch testing. To the best of our knowledge, there have been no studies looking into this topic in Australasia. This cross-sectional study aimed to investigate UV filter, preservative and fragrance allergens in sunscreens commercially sold in supermarkets and pharmacies in New Zealand (NZ).

MATERIALS AND METHODS

A cross-sectional study was conducted through a comprehensive market data review. Major sunscreen suppliers within the Auckland region were identified through Consumer NZ (Dunedin, New Zealand) and AC Nielsen (Auckland, New Zealand). For practical reasons, suppliers with an online product database were included in the study. From March to August 2019, a list of sunscreen ingredients was collated by manually searching through product labels (and manufacturer’s websites if needed) and recording them according to International Nomenclature Cosmetic Ingredient (INCI) names.

UV filters, preservatives and fragrances were recorded for analysis using Microsoft® Excel. Place of sale and cost of sunscreens were also recorded. Statistical analysis was performed using SPSS statistics (version 27, IBM), which included cost analysis and number of NZ baseline series (NZBS) allergens per product. Given the nature of the study being a minimal-risk observational study without human participants, this study was exempt from ethics committee review.

RESULTS

Sixty-three sunscreen suppliers were identified. Eighteen suppliers were excluded as they did not have an online database leaving a total of 95 sunscreens from 45 suppliers for inclusion and study analysis. Thirty-six per cent of sunscreens were sold from supermarkets, 43% from pharmacies and the remainder available from both. The average cost of a sunscreen was \$26 NZD (range \$7 to \$103). Fifty-nine per cent of sunscreens had chemical UV filters, 11% had physical filters, and 30% had both.

Table 1 outlines UV filter, preservative and fragrance allergens in the sunscreens examined. From a total of 21 different UV filters identified, the most frequent was butyl methoxydibenzoylmethane (contained in 70% of products) followed by octocrylene (63%) and homosalate (50%). The common photoallergen benzophenone 3 was found in 19% of products. Phenoxyethanol was the most common preservative (68%) followed by disodium EDTA (30%) and propylparaben (24%). Two sunscreens contained methylisothiazolinone. Sixty-one per cent of sunscreens contained at least one fragrance, the most frequent being limonene (17%) and linalool (13%).

Table 1. Ultraviolet filter, preservative and fragrance allergen ingredients identified in 95 New Zealand sunscreens

	Frequency	%
<i>Filters</i>		
Butyl methoxydibenzoylmethane (avobenzone)	66	69.5
Octocrylene	60	63.2
Homosalate	47	49.5

	Frequency	%
Bis-ethylhexyloxyphenol methoxyphenyl triazine (bemotrizinol)	37	38.9
Titanium dioxide	26	27.4
Ethylhexyl triazone (Uvinul T 150/ Octyl triazone)	23	24.2
Zinc oxide	19	20.0
Benzophenone 3 (oxybenzone)	18	18.9
Ethylhexyl methoxycinnamate (Eusolex 2292/ Uvinul MC80/ octyl methoxycinnamate/ octinoxate)	17	17.9
4-methylbenzylidene camphor	12	12.6
Diethylamino hydroxybenzoyl hexyl benzoate (Uvinul A Plus)	12	12.6
<i>Preservatives</i>		
Phenoxyethanol	65	68.1
† Preservative and fragrance.		

The mean number of NZBS allergens per sunscreen was 1.1 (range 0 to 6, standard deviation 1.27). Almost two thirds of NZ sunscreens contained at least one NZBS allergen, with some containing up to six NZBS allergens. The most frequent NZBS allergens were benzyl alcohol, benzophenone 3, ethylhexyl methoxycinnamate, limonene and linalool. There was no statistically significant correlation between price of sunscreen (\$ per 100ml/mg) and number of NZBS allergens.

DISCUSSION

Australian studies have shown up to 27% of patients reporting sunscreen reactions have relevant positive reactions on patch and photopatch testing.⁵ Similar numbers for NZ are unknown. Historically, inactive ingredients such as preservatives, fragrances, emollients, emulsifiers and thickeners were common causes of irritant contact dermatitis, ACD and PACD to sunscreens. Overtime problematic ingredients have been modified, and now active ingredients, specifically UV filters, have become more frequent culprits.^{3, 4, 15-18}

UV filters

UV filters are relatively uncommon allergens but are common photoallergens. A NZ study of photopatch testing in Auckland found benzophenone 3, a chemical UV filter, to be the commonest cause of PACD.¹⁹ UV filters accounted for 65% of positive photopatch tests in 715 patients who underwent the test at St John's Institute of Dermatology between 1983

and 98.²⁰ There has been a shift in the prevalence of reactions to UV filters influenced by manufacturing, with PABA and its derivatives, once common allergens and photoallergens in the 1960s and 70s being removed from the market due to high sensitisation rates.^{15, 21} This leads to increased use of benzophenones and increased sensitisation and allergy during the 1980s. Subsequently, due to this and environmental impacts of benzophenones another shift is occurring, with butyl methoxydibenzoylmethane predicted to cause the third wave of sunscreen reactions.²²⁻²⁵

Butyl methoxydibenzoylmethane (avobenzone) was the most frequently found UV filter in our study and belongs to the class of dibenzoylmethanes with maximal absorption in the UVA range. It is also the most commonly used UV filter in the United Kingdom and the United States.^{1, 19} Reactions to butyl methoxydibenzoylmethane may occur from cross-reactivity due to previous sensitivity to 4-isopropyl-dibenzoylmethane – which has now been removed from the market..^{4, 22, 26}

Benzophenones were termed the American Contact Dermatitis Society's Allergen of the Year in 2014, and benzophenone 3 has been recognised as the leading allergen and photoallergen within this class.¹ Benzophenone 3 absorbs UVB and UVA II light, and is frequently found in sunscreens and other personal care products to prevent photodegradation. We found 19% of NZ sunscreens contained benzophenone 3. Other studies have shown the proportion of sunscreens containing benzophenone 3 ranged from 30% (2008, the Netherlands) to 68% (2011, the United States).^{27, 28} Due to sensitisation with benzophenone 3, benzophenone 4 has been substituted in some cases and cases of allergic and photoallergic reactions to benzophenone 4 may be increasing.^{24, 29}

Octocrylene is a diphenyl cyanoacrylate derivative and can be grouped with cinnamates given structural similarities. It is a weak UVB filter so it is often combined with other filters to enhance sun protection factor, prevent photodegradation of other UV filters and build water resistance. It is widely used in sunscreens and other topical products, and was found in more than 80% of sunscreens in the Netherlands in 2013, and 20% of skincare cosmetics in the United States in 2014.^{30, 31} Our results are similar to 63% of sunscreens containing octocrylene. Octocrylene is a moderate sensitiser, and contact sensitisation rates range from 0.7% to 5% in those with history of sunscreen intolerance.³¹

Of note, physical UV filters, titanium dioxide and zinc oxide, have not been reported to cause adverse cutaneous reactions. The physical UV protection may even be potent enough to prevent photoallergic reactions to other sunscreen agents.²²

Preservatives

Phenoxyethanol is widely used as a preservative in the cosmetic and industrial fields and was present in 68% of NZ sunscreens. In the past, allergic contact dermatitis due to phenoxyethanol was attributed to 'compound allergy' with the true allergen being methyldibromo glutaronitrile.³² Recent large patch testing trials have demonstrated low

sensitisation rates to phenoxyethanol ranging from 0.1 to 0.24%.³³ Given this safety profile and high efficacy in providing broad-spectrum antimicrobial activity, its prevalence in rinse-off and leave-on cosmetic products continues to rise.³⁴

Parabens were also frequent preservatives in NZ sunscreens. Parabens are commonly found in cosmetics and were previously blamed for greater than 30% of cosmetic-related contact dermatitis.⁴ However, more recent studies have shown they are weak sensitisers despite consumer concerns.^{34, 35} The preservative methylisothiazolinone (MI) has caused many cases of contact allergy worldwide, and very high reported rates of MI sensitisation in Australia have led to legislative change; MI is banned in leave-on products and permitted in rinse-off products only at a reduced concentration of 0.0015%.³⁶ However, MI is still permitted in all products in NZ at a maximum concentration of 0.01% and was concerningly found in two sunscreens in our study.³⁷ Other preservatives found included disodium EDTA, which is a rare sensitiser with only eight reported cases of contact allergy.³⁸ Likewise, chlorphenesin, ethylhexylglycerin and alkyl benzoate are uncommon allergens with few reports of allergy in the current literature.

Fragrances

Fragrance may cause ACD or PACD. Many sunscreen products were labelled with a non-specific 'fragrance' or 'parfum'. Limonene and linalool were the most common named fragrance ingredients. These are common fragrance terpenes with increasing rates of allergy worldwide. Hydroperoxides of limonene and linalool (the allergens produced after oxidation) are now included in many baseline series, including the NZBS. Sensitisation rates to hydroperoxides of limonene and linalool in NZ were recently found to be 1.1% and 1.6%, respectively.³⁹

After limonene and linalool, alpha-isomethyl ionone was the most frequent fragrance found in NZ sunscreens. This is a synthetic fragrance with sensitising potential. A South Korean study found 2% of patients had a relevant positive reaction to alpha-isomethyl ionone on patch testing.⁴⁰ It is not a component of fragrance mix I or II and not included in the NZ or Australian baseline series. Hence, alpha-isomethyl ionone must be tested for specifically if clinically indicated.

Fragrance allergy is common amongst patients presenting for patch testing, and screening with fragrance mixes alone may miss fragrance allergy.⁴¹ As fragrances were common ingredients in NZ sunscreens, we recommended considering testing a fragrance series in patients presenting with sunscreen reactions.

Study limitations

Though a majority of sunscreens are imported from overseas, our findings are relevant to the NZ market and may not be generalisable. Sunscreens from smaller suppliers without online databases were excluded and product ingredients change with time, so it remains

important to check patient's own products.

CONCLUSION

Common allergens including those with high sensitising potential were frequently found in NZ sunscreens, and almost two-third products contained at least one NZBS allergen. Testing additional fragrance allergens should be considered in patients presenting with sunscreen reactions. Knowledge of current product ingredients is useful in planning and interpreting results of patch testing.

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