

Ultraviolet filters in sunscreens and cosmetic products—a market survey

Chayada Chaiyabutr, MD¹; Thanisorn Sukakul, MD^{1,2}; Titinun Kumpangsin, BSc¹; Monthatip Bunyavaree, BSc¹; Norramon Charoenpipatsin, MD¹; Supisara Wongdama, MD¹; Waranya Boonchai, MD¹

¹Department of Dermatology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand

²Department of Occupational and Environmental Dermatology, Lund University, Skåne University Hospital, Malmö, Sweden.

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Waranya Boonchai, MD

Department of Dermatology

Faculty of Medicine, Siriraj Hospital, Mahidol University

2 Wanglang Road, Bangkok Noi

Bangkok 10700, Thailand

Tel: +66 2 419 4333; Fax: +66 2 411 5031

Email: waranya.boonchai@gmail.com

Abstract

Background: As several reports have raised a variety of environment, health and safety issues related to ultraviolet (UV) filters, it is crucial to understand the trends in the exposure of the population to UV filters.

Objective: To determine the frequency of UV filter usage in sunscreens and other cosmetic products in Thai market.

Methods: We surveyed the UV filter labelling on sunscreens and cosmetic products sold in the Thai market. In all, 312 sunscreens and 1,350 other cosmetic products were investigated.

Results: Titanium dioxide was the most frequently used UV filter in both sunscreens (66.7%) and other cosmetic products (68.4%). Ethylhexyl methoxycinnamate was the most common organic UVB filter, whereas butyl methoxydibenzoylmethane was the most common organic UVA filter. In sunscreen aimed at children, bis-ethylhexyloxyphenol methoxyphenyl triazine was the most commonly used UV filter. The most frequent co-occurrence of UV filters was titanium dioxide and ethylhexyl methoxycinnamate.

Conclusions: Titanium dioxide was the most commonly used UV filter, which differs from the findings of previous surveys. Knowing the availability and frequency of each UV filter provides valuable information about consumer exposure levels, facilitates refinements of the allergen series in patch testing, and enhances the monitoring of adverse effects of UV filters.

Keywords: sunscreens, ultraviolet, UV filters, cosmetics, market survey

1. Introduction

Exposure to ultraviolet (UV) radiation can result in many harmful effects on the skin, especially skin cancer and photoaging. There has been a promotion of public awareness of the protection offered by sunscreens against photodamage to the skin. Sunscreens can be used either for recreational or daily life activities. Thus, the global sunscreen market has grown substantially.¹

The photoprotection characteristic of sunscreens is mainly attributed to their constituent UV filters. However, exposure to UV filters is not limited to sunscreens. Many cosmetic products now include the filters, both in response to consumer desire for better UV protection and additional convenience, and to help differentiate the products from others in a highly competitive marketplace. Moreover, UV filters can be used protect those products from the damage caused by the UV component of sunlight. For example, the filters are used in hair care products to protect the colour of dyed hair.

Being cognisant of the trends in UV filter usage by commercial products would be highly beneficial. Not only would it enable the setting of a benchmark of the availability of UV filters in the market, but the frequency of consumer exposure to individual UV filters could also be determined. Moreover, the monitoring of the adverse effects of UV filters would be enhanced, and the updating of the allergen series utilized for patch and photopatch testing would be facilitated. Previous sunscreen-market survey studies were mainly conducted in Europe, and they were performed some years ago.²⁻⁵ Since then, however, UV filters have been altered or reformulated by manufacturers. Moreover, in Asia, where dark skin is undesirable and hyperpigmentation skin problems such as melasma are common concerns, the UV filters selected for incorporation into products might differ from those utilized in other regions. The objective of this study was to reveal the frequency with which UV filters are used in sunscreens and other cosmetic products in the Thai market.

2. Materials and methods

This retrospective study was conducted at the Department of Dermatology, Siriraj Hospital, in April 2020. We identified the ultraviolet filters used in sunscreens and cosmetic products sold in the Thai market by drawing upon the detailed information available from the Contact Allergen Avoidance Program.⁶ This program has been in place since 2010, and its database is continually updated with the ingredients listed on the labels of cosmetic and household products sold in Thailand.

UV filters were identified in the database by using the name of International Nomenclature of Cosmetic Ingredients (INCI), United States Adopted Names (USAN), International Union of Pure and Applied Chemistry (IUPAC), and the trade names of individual UV filters. Products whose labelling identified their primary purpose as sun protection were categorized as sunscreens. The frequencies of the UV filters of sunscreens were ranked and categorized by specific usage (facial, body, child) and formulation (creams, lotions, gels, sprays, others). As to cosmetic products, they were subclassified as facial care, facial powder, liquid foundation makeup, facial cleanser, lip colour, lip care, body care, body cleanser, hair, perfume, and nail products.

The data were analysed with PASW Statistics for Windows, version 18 (SPSS, Chicago, Illinois). Descriptive statistics were presented as frequency and percentage. The difference between the sunscreen groups was tested with the χ^2 test or Fisher's exact test for categorical variables. Differences were further analysed using the pairwise comparison method, with significance values adjusted by the Bonferroni correction for multiple tests. The number of UV filters in the products were compared using the independent-samples Mann-Whitney U test. A *P*-value of $\leq .05$ was deemed statistically significant.

3. Results

In all, 5,444 products were analysed, with one or more UV filters being found in 312 (5.7%) sunscreens and 1,350 (24.8%) other cosmetic products. Titanium dioxide was the most common UV

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filter, followed by ethylhexyl methoxycinnamate (octinoxate) and butyl methoxydibenzoylmethane (avobenzene). The overall occurrences of UV filters in all products, sunscreens, and other cosmetic products are detailed in Table 1. Among all of the analysed products, inorganic UV filters were used more frequently than organic UV filters, especially in cosmetic products. However, there was a statistically significant greater frequency of use of organic UV filters in sunscreens (comprising facial, body and child sunscreen products).

The UV filters used in the sunscreens are categorized by usage and formulation in Tables 2 and 3, respectively. Titanium dioxide was the most frequently labelled filter on facial sunscreens, creams and lotions. Butyl methoxydibenzoylmethane was the most commonly used filter in body sunscreens. As to sunscreens for children, bis-ethylhexyloxyphenol methoxyphenyl triazine (Tinosorb S) was mostly found. Octocrylene was mostly used in sunscreen sprays. The number of inorganic UV filters used in facial sunscreens was significantly higher than that for body sunscreens, but significantly lower in the products aimed at children than those for adults. There were no statistically significant differences in the median numbers of UV filters in facial and body sunscreen or child and non-child sunscreens. When considering the formulations of the sunscreens, sprays had a significantly lower number of inorganic UV filters.

Data on the UV filters used in other cosmetic products, categorized by product type, are illustrated in Figure 1. Titanium dioxide was the most common substance in all cosmetic products except lip care products and perfumes. Perfumes had the highest median number of UV filters in cosmetic products.

The combinations of UV filters in sunscreens and other cosmetic products were also analysed. The co-occurrence of UV filters in sunscreens and other cosmetic products are demonstrated in Tables S1 and S2, respectively. The most frequent co-occurrence in both sunscreens and other cosmetic products was titanium dioxide and ethylhexyl methoxycinnamate.

4. Discussion

In Thailand, UV filters are categorized as cosmetics, as is done in the European Union (EU). Currently, 29 UV filters are permitted for use in cosmetics products including sunscreens in Thailand. The list of approved filters is nearly similar and updated followed to the cosmetic regulations of the European Union (ANNEX VI).⁷ Phenylene bis-diphenyltriazine was the latest approved UV filter in Thailand in 2020 but methoxypropylamino cyclohexenylidene ethoxyethylcyanoacetate which was recently listed in the Annex VI of the EU Cosmetics Regulation, is waiting for the approval in Thailand.⁸ However, the trend of the UV filter usage in sunscreen revealed by our market survey differed greatly from the findings of previous surveys in European countries as titanium dioxide was found to be the leading UV filter by our study (Figure 2). Moreover, our studies showed an increasing trend of the use of inorganic UV filters (titanium dioxide and zinc oxide) and ethylhexyl methoxycinnamate, whereas the use of butyl methoxydibenzoylmethane and octocrylene had a downward trend compared to previous studies.^{2, 4, 5, 9, 10} Titanium dioxide was the most frequent UV filters used that found in our region during the past decade. In our opinion, trend of inorganic filter usage will continue to increase in coming decade.

Usually, a sunscreen contains 2–7 UV filters to achieve a broad spectrum and a high efficacy of photoprotection.^{11, 12} A high number of UV filters has been significantly correlated with a high level of photoprotection.¹³ From our study, the median number (range) of UV filters in the sunscreens was 4 (1, 9), with sunscreen gels and sprays having the highest medians. By comparison, the median number (range) of UV filters used in cosmetic products was 1 (1, 8); the lower median for cosmetic products might be because UV protection is not their primary function.

Titanium dioxide is a photostable, inert, inorganic UV filter that can extend UV protection through the visible light wavelength.¹⁴ We found it is currently the most commonly used UV filter in the sunscreens and cosmetic products sold in the Thai market. This corresponds with the rising trend in inorganic UV filter usage during the last decades.¹⁵ The application of fine particle technology to

titanium dioxide led to the development of a non-greasy and transparent form, which opened the way for the widespread usage of this inorganic filter.¹⁶ However, nanosized inorganic filter which frequently used in commercial products do not protect against visible light. From our study, the term nano was labelled with titanium dioxide and zinc oxide in only 9 and 3 sunscreens, respectively. None of nano inorganic UV filter was detected from cosmetic products label. It was possible that some products in our country missed the “nano” term in labelling as the labelling permission for the “nano” materials in Thailand was complicated. Additionally, the manufacturer might ignore in labelling this term because the majority of consumers did not clearly understand to this word.¹⁷

Apart from its photoprotection property, titanium dioxide can be incorporated as a colourant providing whiteness or opaqueness to various cosmetics products, such as coloured cosmetics, and pressed and loose powders.¹⁶ Additionally, titanium dioxide is found in skin cleansers as a colour-improving agent.¹⁸ When used as a pigment, it may be referred to as titanium white, Pigment White 6 (PW6), or CI 77891.¹⁹ Even though photoprotection might be the secondary function of titanium oxide in cosmetic products, the amount included in coloured cosmetics affects the efficacy of the photoprotection. The opacity of titanium oxide also means that it performs like a thick film, thereby adding another layer of UV protection.²⁰ The popularity of titanium dioxide usage in products sold in the Thai market might be mainly due to its ability to cover the blemishes and brighten the skin. Both attributes are highly desirable among southeast Asian people, which the majority of whom desire white skin and like to conceal pigment spots. Moreover, the advertising catchphrases on the sunscreens using inorganic UV filters that claim to have a low risk of skin allergy or no chemical reaction, are attractive and successful in the cosmetic business. Many consumers seek and choose this kind of product when purchasing.

Zinc oxide, another inorganic UV filter, can be used as a colourant (CI 77947) similar to titanium dioxide.¹⁰ Surprisingly, Zinc oxide was found in only 10.6% of the cosmetic products in spite of its usefulness as a bulking agent, a colourant and a skin protectant.²¹ Zinc oxide was significantly

more commonly used as an ingredient in sunscreens, especially facial sunscreens; this was possibly because the slightly opaque layer of zinc oxide provides good coverage for facial skin. However, zinc oxide has only a modest UV-protecting efficacy.¹⁵ In sunscreen formulations, it was usually combined with titanium dioxide to extend the critical wavelength of the sunscreens. This is because micronized titanium dioxide has lost the ability to provide protection against long-wavelength UVA, whereas zinc oxide has a flat absorption curve across the UV spectra.¹⁵ In our study, zinc oxide and titanium dioxide were found together in 26.5% of the sunscreens and 8% of the cosmetic products.

The most common organic UV filter in our study was ethylhexyl methoxycinnamate (octinoxate). It is primarily a UVB absorber, and it is the most commonly used UVB filter in the United States.^{14, 22} There are many documented reports of allergy and photoallergy to ethylhexyl methoxycinnamate. However, the allergic rate is low when the extensive usage of this UVB filter is taken into account.^{5, 9, 23} It should be therefore be considered a weak sensitizer.

The most frequently used UVA filter in this study was butyl methoxydibenzoylmethane (avobenzone). It is a potent and widely-used UV filter, but it is intrinsically photolabile, losing 50%–60% of its protective efficacy after exposure to UV radiation for 1 hour.¹⁴ To prevent the photodegradation effect, butyl methoxydibenzoylmethane has to be combined with photostable UV filters, such as octocrylene.^{24, 25} Interestingly, despite being non-photostable,²⁶ the combination of butyl methoxydibenzoylmethane and ethylhexyl methoxycinnamate was present in 17.0% and 10.9% of the sunscreens and cosmetic products available in the Thai market, respectively. It needs to be noted that butyl methoxydibenzoylmethane is considered one of the frequent allergens and photoallergens among UV filters.²³

Benzophenone-3 (oxybenzone) is a broad-spectrum, organic UV filter covering the UVB and UVAII wavelengths.²⁷ In this study, it was found in 19.6% and 7.8% of sunscreens and cosmetic products, respectively. Recently, the usage of this UV filter has decreased for many reasons.² Firstly, benzophenone-3 is a potent sensitizer; it is a leading cause of allergic and photoallergic contact

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dermatitis among UV filters, despite having a relatively low rate of usage in sunscreens. Secondly, it has been postulated that coral bleaching might have been partly contributed by this UV filter; this led to a ban of benzophenone-3 in Hawaii in 2021. However, rising ocean temperatures resulting from global warming are another significant cause of coral-reef bleaching.^{28, 29} Lastly, oral ingestion of benzophenone-3 in an animal study was shown to cause an estrogenic effect.³⁰ Nevertheless, this effect could not be demonstrated in a study of topical applications in humans.³¹ The combined effect of all of these drawbacks has been a lessened usage of benzophenone-3.

Benzophenone-4 (sulisobenzene) is a water-soluble, organic UV filter that has a broad spectrum of action resembling benzophenone-3. Because its extinction coefficient is lower than those of other UV filters, it is usually used as an auxiliary in products such as toiletries to prevent photodegradation.³²⁻³⁴ While 8% of the surveyed cosmetic products labelled this UV filter, making it the second most common UV filter in cleansers sold in the Thai market, none of the sunscreens contained it.

Inorganic UV filters have been suggested for use with the paediatric population, especially with children under 2 years of age. As children do not yet have a mature skin structure, and their ratio of body surface area per body weight is higher than that of adults, the risk of systemic absorption from organic UV filters is a concern.³⁵ However, the occurrence of inorganic UV filters in the child sunscreens in our study (46.7%) was significantly lower than that for the non-child formulas. This can be explained by the lack of global regulations for sunscreens aimed at children.

Bis-ethylhexyloxyphenol methoxyphenyl triazine (Tinosorb S), which has been rarely reported as a culprit agent causing allergic contact dermatitis, was mostly used as a UV filter in the child sunscreens. In contrast, benzophenone-3, which is the leading cause of photoallergic contact dermatitis among UV filters, was not detected in the child sunscreens. Sunscreens for children might have a lower chance of producing contact or photocontact allergy than adult sunscreens. However, it is difficult to draw a conclusion as the total number of sunscreens targeting children in the Thai market was low (n = 15). As Thais have a high skin phototype and a low incidence of sunburn,

providing sun protection for children—including the use of sunscreens—may not be of much concern to their parents.

Creams and lotions have been reported to be the most common sunscreen formulations sold, with a combined market share exceeding 80%.¹¹ Very few gel and spray sunscreen formulations are sold in the Thai market. This is despite such formulations being less sticky than creams and lotions and therefore better suited for use in a hot and humid country like Thailand. In contrast, a recent study revealed that there is an increasing trend in the sales of sunscreen sprays in the USA because of their quick, non-greasy and easy application.¹ The disadvantages of the spray formulation are an inadequate or non-uniform application, and the possible development of aerosol inhalation-related lung injuries, especially if a product contains inorganic UV filters.^{1, 15, 36} The current survey found that inorganic UV filters had a significantly lower frequency of use (13.3%) in spray formulations than in creams, lotions and gels. In addition, all of inorganic UV filters labelled on spray products were non-nano-sized particles. As the nano-sized inorganic UV filters were prohibited in spray form because of the inhalation risk. UV protection in those products was provided instead by a number of organic UVB and UVA filters, especially butyl methoxydibenzoylmethane and octocrylene. Similarly, the frequency of use of inorganic filters in gels was lower than in creams and lotions. Inorganic filters are not easy to formulate as gels because of the aggregation of these filters, which results in an unwanted opaqueness of the end-product.³⁷ All of the gel formulations in the Thai market were found in facial sunscreens.

As exposure to UV filters is not limited to sunscreens, cosmetic products—a significant source of UV filter exposure—were also analysed by the current study. However, the purpose of adding these filters to cosmetic products is not limited to photoprotection. Sometimes, inorganic UV filters are used as a pigment or as an opacifier.^{16, 18} Not surprisingly, then, the present research revealed that there was a high frequency of inorganic UV filter usage among the cosmetic products designed for use on the face, or as a colouring agent or toiletry. Moreover, several UV filters can be used to protect light-sensitive products and their ingredients from the degradation effects of UV

radiation (such as colour fading and scent decomposition). In turn, this extends the shelf lives of products, especially perfumes, which were found by our study to have the highest median number of UV filters.^{3, 32, 38} As to organic UV filters, the current study found that the perfumes contained several filters that have been reported to produce contact and photocontact allergies, such as butyl methoxydibenzoylmethane and benzophenone-3. To our knowledge, however, organic UV filters in perfumes neither cause contact sensitization nor elicitation, most probably due to their low concentrations in perfumes. Further investigation may be required.

Apart from cutaneous cosmetics, UV filters are also found in lip products. UV protection of the lips helps to prevent the development of lip cancers and the reactivation of herpes.^{5, 39} The present work found that the lip colour products mainly contained titanium dioxide, whereas the lip care products primarily utilised organic UV filters, such as ethylhexyl methoxycinnamate and butyl methoxydibenzoylmethane. Benzophenone-3, a potent UV filter sensitizer, was found in 19% of the lip care products. Clinicians should be aware that cases of contact cheilitis may have resulted from the use of UV filters in lip care products.

One limitation of our study was that the product labelling of the cosmetic products containing UV filters generally did not state the intended function or the concentration of those filters. Without the concentration details, we were unable to determine whether those products complied with the current Thai regulations on UV filter usage.

In conclusion, this study demonstrated the occurrence of UV filters in sunscreens and cosmetic products in the Thai market. There are several emerging issues relating to human health and the environmental effects of UV filters, such as the toxic effects of nanoparticles, systemic absorption, cutaneous allergies, and the impact on the marine ecosystem. Detailed information about the trends in UV filter exposure can be used as an input to discussions about such matters, as well as to guide sunscreen selection and monitor the adverse effects of the filters.

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Table 1. Frequency of UV filters in all products, sunscreens and other cosmetic products

UV filter (INCI)	All		Sunscreens		Other Cosmetic products		Sunscreen versus other cosmetic products <i>P-value</i>
	N = 1,662		N = 312		N = 1,350		
	N	%	N	%	N	%	
<i>Inorganic absorbers</i>	1,183	71.2	226	72.4	957	70.9	.587
- Titanium dioxide	1,131	68.1	208	66.7	923	68.4	.561
- Zinc oxide	245	14.7	102	32.7	143	10.6	< .001
<i>Organic absorbers</i>	983	59.1	268	85.9	715	53.0	< .001
<i>Organic UVB absorbers</i>							
<i>Cinnamates</i>							
- Ethylhexyl methoxycinnamate	598	36.0	175	56.1	423	31.3	< .001
- Isoamyl p-methoxycinnamate	13	0.8	4	1.3	9	0.7	.282
<i>Diphenylcyanoacrylate</i>							
- Octocrylene	235	14.1	122	39.1	113	8.4	< .001
<i>Salicylate</i>							
- Ethylhexyl salicylate	191	11.5	94	30.1	97	7.2	< .001
- Homosalate	83	5.0	58	18.6	25	1.9	< .001
<i>Camphor</i>							
- 4-Methylbenzylidene camphor	14	0.8	13	4.2	1	0.1	< .001
<i>PABA</i>							
- Ethylhexyldimethyl PABA	5	0.3	1	0.3	4	0.3	> .99

- PABA	1	0.1	–	–	1	0.1	> .99
<i>Triazones</i>							
- Ethylhexyl triazone	56	3.4	47	15.1	9	0.7	< .001
- Diethylhexyl butamido triazone	7	0.4	5	1.6	2	0.1	.003
<i>Miscellaneous</i>							
- Phenylbenzimidazole sulfonic acid	116	7.0	35	11.2	81	6.0	.001
- Polysilicone-15	17	1.0	14	4.5	3	0.2	< .001
<i>Organic UVA absorbers</i>							
<i>Dibenzoylmethanes</i>							
- Butyl methoxydibenzoylmethane	364	21.9	132	42.3	232	17.2	< .001
<i>Benzophenones</i>							
- Benzophenone-3	166	10.0	61	19.6	105	7.8	< .001
- Benzophenone-4	113	6.8	–	–	113	8.4	< .001
- Benzophenone-5	9	0.5	–	–	9	0.7	.223
<i>Camphor</i>							
- Terephthalylidene dicamphor sulfonic acid	40	2.4	33	10.6	7	0.5	< .001
<i>Anthranylates</i>							
- Menthyl anthranilate	13	0.8	1	0.3	12	0.9	.482
<i>Miscellaneous</i>							
- Diethylamino hydroxy benzoyl hexyl benzoate	66	4.0	44	14.1	22	1.6	< .001
<i>Organic UVA and UVB absorbers</i>							
- Bis-ethylhexyloxyphenol methoxyphenyl triazine	118	7.1	97	31.1	21	1.6	< .001
- Drometrizole trisiloxane	46	2.8	38	12.2	8	0.6	< .001
- Methylene bis-benzotriazolyl tetramethylbutylphenol	38	2.3	29	9.3	9	0.7	< .001

Number of different UV filters in products median (min, max)	1 (1, 9)	4 (1, 9)	1 (1, 8)	< .001
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<i>Dibenzoylmethanes</i>										
- Butyl methoxydibenzoylmethane	95	37.7	30	66.7	< .001	7	46.7	125	42.1	.726
<i>Benzophenones</i>										
- Benzophenone-3	48	19.0	13	28.9	.132	–	–	61	20.5	.049
- Benzophenone-4	–	–	–	–	–	–	–	–	–	–
- Benzophenone-5	–	–	–	–	–	–	–	–	–	–
<i>Camphor</i>										
- Terephthalylidene dicamphor sulfonic acid	29	11.5	2	4.4	.153	2	13.3	31	10.4	.665
<i>Anthranilates</i>										
- Menthyl anthranilate	1	0.4	–	–	> .99	–	–	1	0.3	> .99
<i>Miscellaneous</i>										
- Diethylamino hydroxy benzoyl hexyl benzoate	41	16.3	2	4.4	.038	1	6.7	43	14.5	.704
<i>Organic UVA and UVB absorbers</i>										
- Bis-ethylhexyloxyphenol methoxyphenyl triazine	77	30.6	12	26.7	.600	8	53.3	89	30.0	.083
- Drometrisole trisiloxane	34	13.5	1	2.3	.031	3	20.0	35	11.8	.407
- Methylene bis-benzotriazolyl tetramethylbutylphenol	23	9.1	4	8.9	> .99	2	13.3	27	9.1	.639

Number of UV filters in products	4 (1, 9)	4 (1, 9)	.649	4 (1, 8)	4 (1, 9)	.642
median (min, max)						

Table 3. Frequency of UV filters in sunscreens, categorized by formulation

UV filter (INCI)	Creams		Lotions		Gels		Sprays		Others ^α		P-value
	N = 162		N = 97		N = 17		N = 15		N = 21		
	N	%	N	%	N	%	N	%	N	%	
<i>Inorganic absorbers</i>	127	78.4	74	76.3	11	64.7	2	13.3 ^{*,†,‡}	12	57.1 [¥]	< .001
- Titanium dioxide	119	73.4	66	68.0	9	52.9	2	13.3 ^{*,†}	12	57.1	< .001
- Zinc oxide	64	39.5	30	30.9	4	23.5	1	6.7	3	14.3	.017
<i>Organic absorbers</i>	129	79.6	88	90.7	16	94.1	15	100.0	20	95.2	.017
<i>Organic UVB absorbers</i>											
<i>Cinnamates</i>											
- Ethylhexyl methoxycinnamate	99	61.1	52	53.6	10	58.8	4	26.7	10	47.6	.099
- Isoamyl p-methoxycinnamate	3	1.9	–	–	–	–	–	–	1	4.8	.394
<i>Diphenylcyanoacrylate</i>											
- Octocrylene	47	29.0	44	45.4	7	41.2	14	93.3 ^{*,†,‡}	10	47.6	< .001

- Butyl methoxydibenzoylmethane	64	39.5	39	40.2	6	35.3	13	86.7 ^{*,†,‡}	10	47.6	.010
<i>Benzophenones</i>											
- Benzophenone-3	34	21.0	23	23.7	1	5.9	2	13.3	1	4.8	.161
- Benzophenone-4	–	–	–	–	–	–	–	–	–	–	–
- Benzophenone-5	–	–	–	–	–	–	–	–	–	–	–
<i>Camphor</i>											
- Terephthalylidene dicamphor sulfonic acid	10	6.2	17	17.5 [*]	3	17.6	2	13.3	1	4.8	.040
<i>Anthranilates</i>											
- Menthyl anthranilate	1	0.6	–	–	–	–	–	–	–	–	.921
<i>Miscellaneous</i>											
- Diethylamino hydroxy benzoyl hexyl benzoate	14	8.6	15	15.5	10	58.8 ^{*,†}	2	13.3 [‡]	3	14.3 [‡]	< .001
<i>Organic UVA and UVB absorbers</i>											
- Bis-ethylhexyloxyphenol methoxyphenyl triazine	37	22.8	32	33.0	11	64.7 [*]	9	60.0 [*]	8	38.1	< .001
- Drometrizole trisiloxane	10	6.2	17	17.5	7	41.2 [*]	2	13.3	2	9.5 [‡]	< .001
- Methylene bis-benzotriazolyl tetramethylbutylphenol	20	12.3	6	6.2	1	5.9	–	–	2	9.5	.324

Number of UV filters in products	4 (1, 8)	4 (1, 9)	5 (2, 9)	5 (3, 8)*	5 (2, 6)	.002
median (min, max)						

^a Other formulations of sunscreens include formulations other than creams, lotions, gels or sprays, such as solutions.

* Significant difference to creams; [†] significant difference to lotions; [‡] significant difference to gels; [§] significant difference to sprays

Figure legends

Figure 1. Percentage of frequency of UV filter usage in other cosmetic products, categorized by type of product

Figure 1a: Percentage of frequency of UV filter usage in facial products

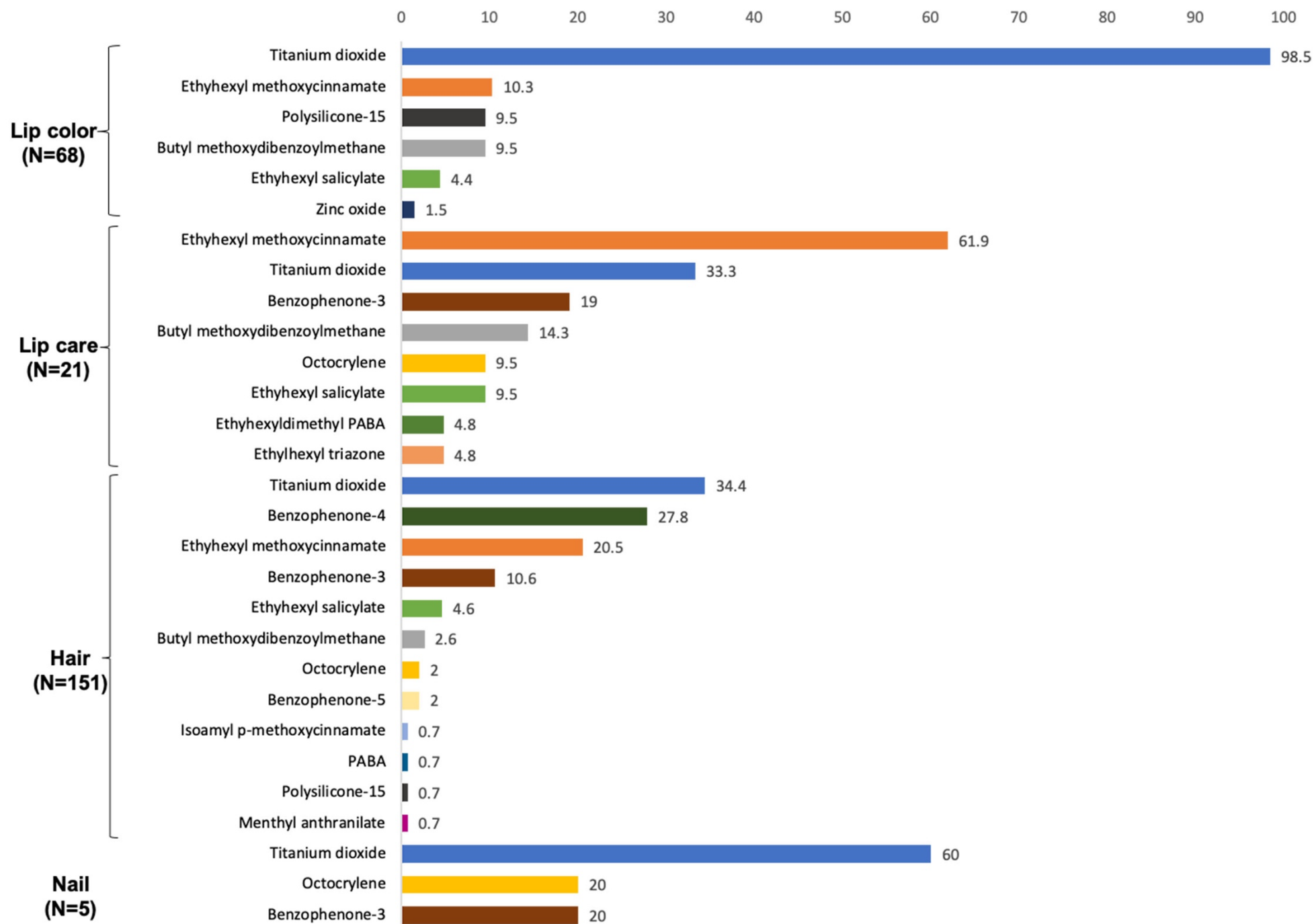
Figure 1b: Percentage of frequency of UV filter usage in lip, hair and nail products

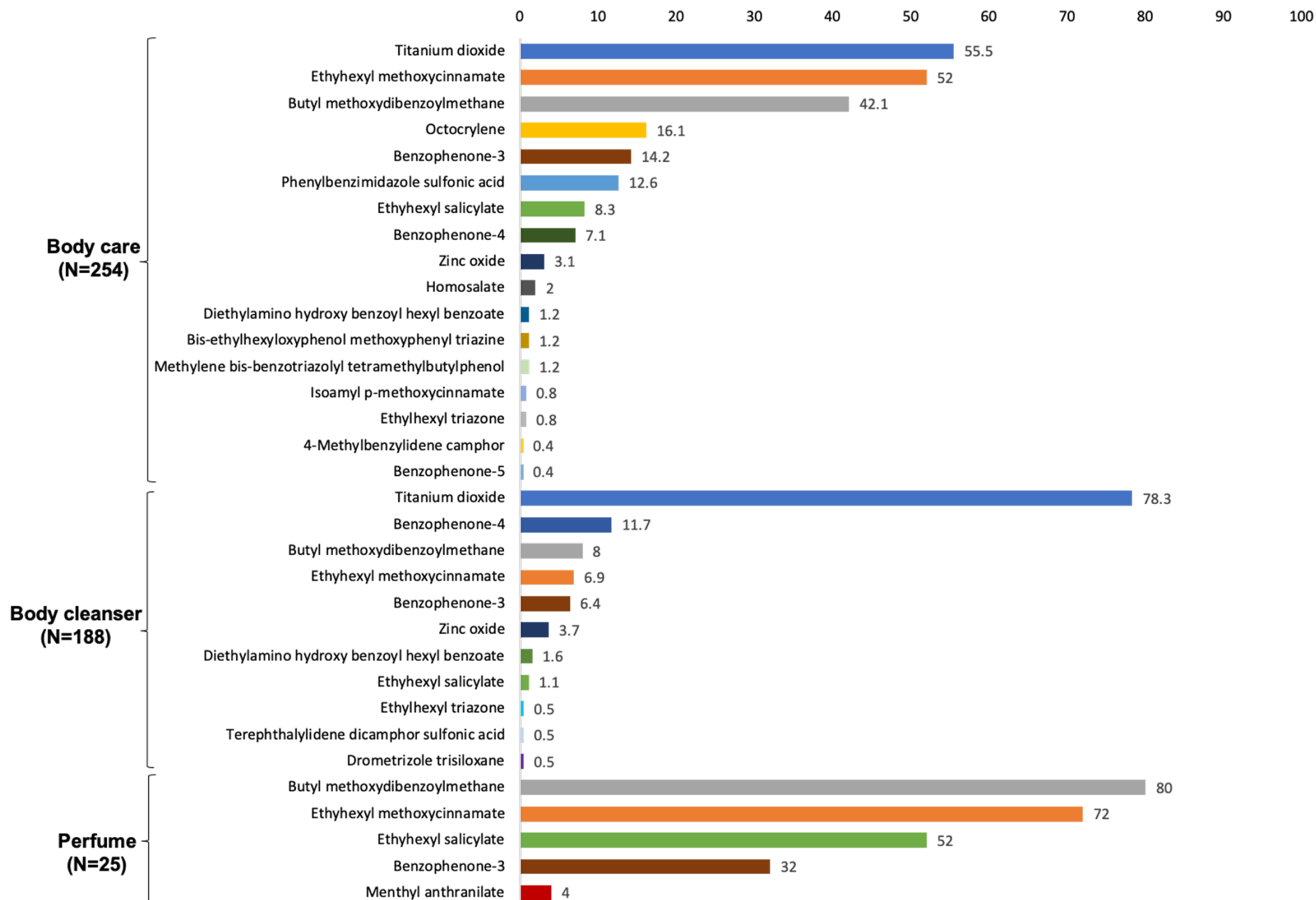
Figure 1c: Percentage of frequency of UV filter usage in body and perfume products

Footnote to Figure 1: The median number (range) of each cosmetic product is as follows: facial care: 2 (1, 6); facial powder: 1 (1, 4); liquid foundation makeup: 1 (1, 5); facial cleanser: 1 (1, 3); lip colour: 1 (1, 4); lip care: 2 (1, 3); body care: 2 (1, 8); body cleanser: 1 (1, 5); hair: 1 (1, 2); perfume: 3 (1, 4); nail: 1 (1, 1)

Figure 2: Percentage of common UV filter usage in sunscreen comparing to previous survey







Denmark
2001 (n=75)



United Kingdom
2005 (n=308)



Germany
2006-2009 (n=462)



United Kingdom
2010 (n=337)



Thailand
2010-2020 (n=312)



0 50 100 150 200 250 300 350 400



Table S1 Co-occurrence of ultraviolet filters in sunscreen (N=312)

[illegible]

Table S2 Co-occurrence of ultraviolet filters in cosmetic products (N=1350)

[illegible]