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Korean Standard Series allergens and emerging sources: a narrative review

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Purpose: This study aimed to address gaps in Korean Standard Series (KSS) information, highlight allergens with increasing patch test positivity, describe potential sources encountered in daily life, and provide guidance on selecting allergen-free alternatives.

Methods: Relevant information was identified from KSS patient instruction sheets (Chemotechnique, Sweden), T.R.U.E. TEST patient instruction sheets (SmartPractice, United States), the Contact Dermatitis Institute allergen database, the American Contact Dermatitis Society allergen information sheets, and searches of the PubMed database. English-language review articles, case series, and case reports identified using keywords related to the 25 KSS allergens were selected.

Results: Information was updated for the following allergens: nickel, cobalt, potassium dichromate, balsam of Peru, paraben mix, *N*-isopropyl-*N*'-phenyl-*p*-phenylenediamine, formaldehyde, *p-tert*-butylphenol formaldehyde resin, methylchloroisothiazolinone/methylisothiazolinone, colophonium, imidazolidinyl urea, and 2-mercaptobenzothiazole. Emerging sources included electronic devices, personal protective equipment, including masks whose use increased during the COVID-19 (coronavirus disease 2019) pandemic, nail products, and children's toy slime. In addition, occupational allergen information sheets were developed for hairdressers, healthcare workers, dentists, dental hygienists, and cooks. The Korean-language allergen sheets are provided in the Supplementary Materials.

Conclusion: Because the KSS has not been revised for more than 2 decades, emerging allergen sources may be inadequately represented in the existing patient information. Accordingly, updated patient instruction sheets were developed to improve patient understanding and facilitate the practical application of patch test results.

Keywords: Allergens; Allergic contact dermatitis; Guideline; Patch tests; Patient education

Introduction

Background

Patch testing is essential for identifying allergens responsible for allergic contact dermatitis (ACD) and guiding allergen avoidance through appropriate lifestyle modifications. However, existing allergen information sheets may omit emerging sources of exposure and may be difficult for patients to interpret, potentially limiting their understanding of patch test results. Clear patient education is important because patients may have difficulty recalling their patch test results and the specific allergens they should avoid over time [1].

Objectives

This review summarizes contact allergens, cross-reactors, and relevant dietary restrictions associated with the 25 allergens included in the Korean Standard Series (KSS), with an emphasis on exposures encountered in daily life.

Methods

Ethics statement

Because this study was based exclusively on published literature and other publicly available information, institutional review board approval and informed consent were not required.

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Study design

This narrative review was based on a search of the academic literature and other relevant information sources.

Information sources and search strategy

A comprehensive literature search was conducted to identify emerging sources, cross-reactors, and occupational exposure risks associated with the 25 allergens included in the KSS. The primary academic literature search was conducted in PubMed using combinations of terms specific to the 25 KSS allergens together with terms such as "allergic contact dermatitis," "allergen sources," and "cross-reactivity."

To support patient education, established patch test databases and commercially available patient instruction materials were reviewed alongside the academic literature. These sources included the KSS patient instruction sheets [2] (Chemotechnique, Sweden), T.R.U.E. TEST patient instruction sheets [3] (SmartPractice, United States), the Contact Dermatitis Institute allergen database [4], and the American Contact Dermatitis Society allergen information sheets [5].

Selection process

The academic literature was limited to English-language review articles, case series, and case reports. Studies were selected if they described recent trends in everyday allergen exposure, including exposures associated with modern electronic devices, personal protective equipment, and cosmetics. Publications describing specific dietary restrictions and occupational exposure risks were also included. Information from the selected sources was synthesized to develop an updated guide for patient education and allergen avoidance.

Results

KSS allergens

The allergens are presented in order of patch test positivity rates, as reported by Kwon et al. [6]. Table 1 summarizes the allergens and their sources, and Table 2 summarizes emerging sources [7-46]. The Korean-language allergen sheets are provided in the Supplement 1.

Nickel (II) sulfate hexahydrate

Nickel is widespread in the modern environment and reportedly causes contact dermatitis more frequently than other metals. Common sources include everyday metallic items such as coins, keys, paper clips, needles, tools, and lighters. Nickel is also present in faucets, kitchen utensils, washing machines, tumblers, and electronic devices, including cell phones, laptops, tablets, AirPods, and smartwatches [7-9]. Reactions may be more pronounced in moist conditions, such as after sweating. Prolonged contact between water and a metal pot may increase nickel release, so it is advisable to replace the water after each use. Additional sources include razors, eye cosmetics, tattoo inks—particularly green and blue inks and, less commonly, brown and violet inks—nail polish, and nail tips or stickers [10-13]. Fashion items, including watches, eyeglass frames, zippers, buttons, belt buckles, and jewelry made of white gold, 14K gold, chrome, copper, or tin, may also contain nickel. Orthopedic and dental prostheses, such as dental braces, as well as insulin pumps and blood glucose meters, may contain nickel [14,15]. Industrial sources include pesticides, paint pigments, putty, catalysts, wires, and machinery.

Patients are advised to avoid soy products (e.g., soy milk, miso, and tofu), nuts (e.g., almonds and peanuts), cereals, vitamin supplements, and chocolate products. Meat may be preferable to seafood, such as shrimp and clams [47]. Smoking cessation is strongly advised because cigarettes contain nickel. Direct contact with metal items in daily life should be minimized; unavoidable objects, such as doorknobs, may be covered with fabric. Potentially safer alternatives include aluminum, gold, silver, and platinum. Although stainless steel contains nickel, allergic reactions are uncommon because it generally releases only small amounts. Nevertheless, nonstick-coated cookware is considered preferable to stainless-steel cookware. Co-sensitization may occur with palladium, cobalt, chromium, and other metals.

Cobalt (II) chloride hexahydrate

Cobalt is present in metallic items such as keys, magnets, zippers, buttons, belt buckles, jewelry, and tools, as well as in electronic devices such as cell phones. It is also found in light-brown pigments used in products such as hair dyes and tinted cosmetics; blue pigments used in tattoos, inks, and porcelain glazes; glass; and nail tips or stickers [13]. In industrial settings, cobalt salts may be encountered in bricks, wet cement, paint, tire manufacturing, plastic processing, welding, and animal feed.

Patients may be advised to avoid foods containing whole grains (e.g., flaxseed), legumes (e.g., chickpeas), nuts, apricots, beets, cabbage, beer, tea, coffee, cocoa, chocolate, cloves, liver, and scallops, as well as vitamin B12 supplements. Orthopedic and dental prostheses may also contain cobalt. Silver and stainless-steel products may be suitable alternatives. Small items such as keys can be coated with nail polish, whereas larger items such as scissors can be coated with plastic. Co-sensitization may occur with other metals, including nickel and chromium.

Table 1. Overview of the Korean Standard Series allergens and their sources

No.	Allergen	Personal care products	Clothing or jewelry	Medical products	Rubber products	Cleaning products	Industrial products
1	Nickel		V				V
2	Lanolin	V	V	V		V	V
3	Neomycin sulfate			V			V
4	Potassium dichromate		V	V			V
5	Mercury ammonium chloride	V		V			V
6	Fragrance mix I	V		V		V	V
7	Colophonium	V		V		V	V
8	Imidazolidinyl urea	V		V		V	V
9	Clioquinol	V		V		V	V
10	Balsam of Peru	V		V		V	V
11	IPPD		V		V		V
12	Cobalt		V				V
13	PTBP	V	V			V	V
14	Paraben mix	V		V			V
15	Captan	V					V
16	Budesonide	V		V			V
17	MCI/MI	V		V		V	V
18	Quaternium-15	V		V		V	V
19	MBT		V	V	V		V
20	PPD	V	V		V		V
21	Formaldehyde	V	V			V	V
22	Mercapto mix		V	V	V		V
23	Thimerosal	V		V			V
24	Thiuram mix		V	V	V		V
25	Tixocortol-21-pivalate	V		V			

IPPD, *N*-isopropyl-*N*′-phenyl-p-phenylenediamine; PTBP, *p*-*tert*-butylphenol formaldehyde resin; MCI/MI, methylchloroisothiazolinone/methylisothiazolinone; MBT, 2-mercaptobenzothiazole; PPD, *p*-phenylenediamine.

Potassium dichromate

Potassium dichromate has various industrial applications and may be encountered in stainless steel items, including tools, watches, rings, earrings, bracelets, and belts, as well as in orthopedic and dental prostheses and surgical catgut sutures. Additional sources include sterling silver (925 silver), detergents, cosmetics, nail tips or stickers, green pigments used in products such as tattoo inks and porcelain glazes, and photographic developers [13]. Potassium dichromate is also used in leather tanning and may therefore be present in leather goods and furs, including footwear, gloves, steering wheels, and handbags. Vegetable-tanned leather may provide an alternative.

Dietary recommendations include avoiding apple peels, canned fruits, grapes, potatoes, meat, nuts, chocolate, spices, tea, wine, beer, multivitamins, and chromium picolinate supplements. In occupational settings, exposure to sand, matches, ash, treated wood, wet cement, and mortar should be minimized. Alternatives include cement with reduced dichromate content or cement supplemented with ferrous sulfate. Metalworking fluids should be changed regularly during machining operations.

Balsam of Peru (Myroxylon pereirae resin)

Balsam of Peru, an aromatic resinous liquid, is used as a fragrance or flavoring component in products such as air fresheners, deodorants, candles, mouthwashes, toothpastes, shampoos, soaps, moisturizers, fragrances, essential oils, aromatherapy products, diapers, and baby powders. It may also be present in ointments, dressings, dental adhesives, pesticides, insect repellents, and scented tobacco products.

Foods and flavorings that may need to be avoided include allspice, cinnamon, vanilla, citrus products, paprika, nutmeg, cloves, curry, chili sauce, ketchup, tomatoes, pickles, pastries, sweets, ice cream, candy, chewing gum, chocolate, soft drinks, and alcoholic beverages [14]. Products labeled as "unscented" may still contain masking fragrances related to Balsam of Peru. Potential cross-reactors include fragrance mix, cedarwood, musk, orange peel extract,

Table 2. Allergens with emerging sources

Allergen	Sources
Nickel	• Diabetes-related medical devices (glucose sensors, insulin pumps) [15], stainless steel skull pins [40], metal dental braces [41], nitinol stent graft (rarely) [42]
	• Metallic hairdressing tools (tweezers, sectioning clips, hair clips, straight razors, crochet hooks, tail combs) [37]
	• Tattoo inks (green, blue > brown, violet) [11]
	• Microblading eyebrow tattooing [43]
	• Eyebrow pencil [10]
	• Mobile phones, laptop computers, video game controllers [7], AirPods [8], smartwatches (e.g., Apple Watch) [9]
	• Nail tips and nail stickers [13], nickel mixing beads in nail polish [12]
	• Dance poles [44]
	• Piercings [14]
	• Figs, raspberries [14]
Potassium dichromate	• Nail tips and nail stickers [13]
Colophonium	• Diabetes-related medical devices (adhesives for glucose sensors, insulin pumps) [15]
	• Medical adhesives (adhesive tapes, adhesive bandages, and suture adhesives) [35]
	• Safety illustration printed on medical devices [45]
	• Wearable health devices [33]
	• Beeswax wraps [46], depilatory wax [16]
	• Disposable paper napkins [38]
	• Christmas trees [39]
	• Sanitary pads [34]
Imidazolidinyl urea	• Ultrasound gels [32]
Balsam of Peru	• Cookies, tomatoes, ice cream, chutney, cola, ketchup, chocolate, alcoholic beverages [14]
IPPD	• Black rubber vehicle handbrake handles [20]
	• Galaxy Fit strap [19]
	• Gas masks [21]
Cobalt	• Metallic hairdressing tools (tweezers, sectioning clips, hair clips, straight razors) [37]
	• Nail tips and nail stickers [13]
PTBP	• Artificial nails [29]
	• Athletic tape [29]
	• Swimming goggles [27]
	• Basketballs [28]
Paraben mix	• Strawberries, blueberries, grapes, olives, yeast, barley [18]
	• Children's toy slime [17]
MCI/MI	• Children's nail polish [30]
	• Cosmetic glitter adhesive [31]
	• Children's toy slime [17]
	• Ultrasound gels [32]
MBT	• Elastic diaper edges [36]
Formaldehyde	• Eyelash adhesives [22]
	• Nail hardeners [12]
	• Tattoo inks [24]
	• Cigarette smoke [23]
	• Backpack shoulder straps [25]
	• Surgical polypropylene N95 (FFP2) respirators [26]
	• Cod, caviar, coffee, shiitake mushrooms, smoked ham, maple syrup, aspartame [14]

IPPD, *N*-isopropyl-*N*'-phenyl-*p*-phenylenediamine; PTBP, *p*-*tert*-butylphenol formaldehyde resin; MCI/MI, methylchloroisothiazolinone/methylisothiazolinone; MBT, 2-mercaptobenzothiazole.

propolis, beeswax, turpentine, tolu balsam, copaiba balsam, rosin, wood tar, *Krameria triandra*, coumarin, and diethylstilbestrol.

Thimerosal

Thimerosal, which is now rarely used, was previously a common antiseptic in medical products and has largely been replaced by other preservatives. It may still be present in some contact lens solutions, vaccines, antitoxins, disinfectants, cosmetics, and cleansing products and has also been used as a fluorescent dye in forensic applications.

Patients with thimerosal allergy should inform their healthcare providers; however, medically indicated vaccination should not be delayed solely because of this allergy. Many vaccines intended for young children are thimerosal-free, and although some adult vaccines may contain thimerosal, thimerosal-free alternatives are often available.

Fragrance mix I

Fragrance mix I contains cinnamyl alcohol, cinnamaldehyde, amyl cinnamaldehyde, hydroxycitronellal, geraniol, eugenol, isoeugenol, and oakmoss absolute. These substances are commonly used as fragrance ingredients in air fresheners, deodorants, incense, candles, detergents, fabric softeners, mouthwashes, toothpastes, shampoos, soaps, moisturizers, perfumes, essential oils, and herbal or botanical products. Products marketed as unscented may contain fragrance ingredients used to mask other odors. Components of fragrance mix I or related fragrance substances may also be encountered in ointments, disinfectants, dental cement, pesticides, paper products, and scented tobacco. When selecting topical products, patients should also be aware of ingredients such as propolis, tea tree oil, and other plant-derived oils.

Related fragrance and flavoring substances may also be used in candy, ice cream, chewing gum, and soft drinks. Patients with clinically significant fragrance allergy may need to avoid cinnamon, cloves, vanilla, and citrus flavorings, including citrus peel. Cross-reactions may occur with Balsam of Peru, daffodil, sandalwood oil, and citronella.

Paraben mix

Parabens are widely used preservatives in personal care products such as shampoos, soaps, and moisturizers, as well as in toothpastes, cosmetics, quick-drying nail polish, hair dyes, certain fabrics, and children's toy slime [17]. They may also be present in bandages, local anesthetic preparations, and topical medications. Some individuals with positive patch test reactions to parabens may tolerate paraben-containing products; however, products associated with a skin reaction should be discontinued.

Parabens may be used as preservatives in foods such as mayonnaise, salad dressings, ketchup, hot sauce, mustard, processed fruits and vegetables (e.g., olives), dairy products, baked goods, jellies, jams, soft drinks, syrups, and candy [18]. Ingestion of foods containing permitted parabens as preservatives is generally considered safe.

N-isopropyl-N'-phenyl-p-phenylenediamine

N-isopropyl-*N*'-phenyl-*p*-phenylenediamine (IPPD) is an antioxidant used in rubber manufacturing and is present in black rubber products such as smartwatch straps, disposable mask straps, handle grips on cookware, exercise equipment, and vehicle handbrakes, sports tape, shoe insoles, and rubber gloves [19,20]. It may also be present in photographic materials and printer inks. Occupational sources include grease, lubricants, gasoline, gas masks, automobile tires, and brake linings [21]. IPPD may cross-react with *p*-phenylenediamine (PPD), a common ingredient in hair dye.

Tixocortol-21-pivalate

Tixocortol-21-pivalate is a group A corticosteroid used in topical preparations. Cross-reactivity may occur with other corticosteroids, including budesonide (Pulmicort), desonide (DesOwen), fludrocortisone, hydrocortisone (LactiCare), triamcinolone, methylprednisolone (Advantan), prednisolone (Lidomex), and prednicarbate (Dermatop).

Formaldehyde

Formaldehyde is widely used as a preservative, disinfectant, and industrial chemical and may be present in hair products, cosmetics, nail polish, nail hardeners and removers, eyelash adhesives, fabrics, and pottery glazes [12,22]. Other reported sources include tobacco smoke, photographic developers, tattoo inks, and backpack shoulder straps [23-25]. To reduce exposure from clothing, newly purchased garments may be washed several times in hot water before use, and wrinkle-resistant clothing may be avoided when relevant.

Foods reported to contain formaldehyde include cod, caviar, shiitake mushrooms, smoked ham, maple syrup, aspartame-containing products, coffee, and chewing gum [14]. Occupational and environmental sources include N95 respirators, wood smoke, exhaust fumes, paint, pesticides, fungicides, adhesives, plywood, coolants, and insulating materials [26]. Cross-reactions may occur with formaldehyde-releasing preservatives such as quaternium-15, bronopol, dimethylol dimethyl hydantoin, diazolidinyl urea, and imidazolidinyl urea.

p-Phenylenediamine

PPD is present in hair dyes, black rubber products, black pigments used in products such as henna preparations, printer inks, lithographic materials, and photographic developers, and black-dyed fabrics, furs, and footwear. Occupational sources may include grease, oils, and gasoline. Patients are advised to avoid relevant dyed clothing, fabrics, and furs because of possible reactions to related dyes containing phenylenediamine compounds. Cross-reactions may occur with aniline yellow, disperse orange dyes, and *p*-toluenediamine.

Mercury ammonium chloride

Mercury compounds have historically been used as fungicides and antiseptics and may be encountered in products such as disinfectants (e.g., Mercurochrome), skin-lightening creams, mascara, dental amalgam, fluorescent lamps, batteries, and scientific instruments such as thermometers, barometers, and liquid-mirror telescopes. However, the use of mercury-containing products has declined globally following implementation of the Minamata Convention. Seafood may nevertheless contain trace amounts of mercury.

Thiuram mix

Thiuram mix contains tetramethylthiuram disulfide, tetramethylthiuram monosulfide, and tetraethylthiuram disulfide. Thiurams are used as rubber accelerators and may be present in rubber gloves, bands, mats, handle grips, electrical cords, earphones, erasers, makeup sponges, goggles, swimwear, wetsuits, tires, masks, tubing, hoses, and some soaps. Medical sources include stethoscopes, tourniquets, dental rubber dams, and condoms. Occupational exposure may occur through pesticides and fungicides as well as through the manufacture or handling of tires, masks, tubing, and hoses.

Patients with thiuram allergy should avoid relevant natural and synthetic rubber products and use vinyl, plastic, leather, wood, or fabric alternatives when feasible. If contact with an allergen-containing item cannot be avoided, a physical barrier such as fabric or plastic film may reduce direct skin contact. Patients should also be aware of possible reactions to disulfiram, a medication used to treat alcohol dependence.

Neomycin sulfate

Neomycin is a topical aminoglycoside antibiotic found in products such as Madecassol. Cross-reactions may occur with other aminoglycoside antibiotics, including butirosin, framycetin, mycifradin, gentamicin, kanamycin, streptomycin, sisomicin, spectinomycin, paromomycin, and fradiomycin. Concomitant allergy to bacitracin (Baspo) may also occur. Alternative topical agents that do not contain neomycin include mupirocin preparations such as Bactroban and Esroban and povidone-iodine products such as Betadine.

p-tert-Butylphenol formaldehyde resin

p-tert-Butylphenol formaldehyde resin (PTBP) is used primarily as an adhesive in leather and rubber products. Reported sources include disposable masks, sports tape, swimming goggles, basketballs, deodorants, lip liners, artificial nails, nail adhesives, shoes, belts, and handbags [27-29]. PTBP may also be present in furniture adhesives, billiard balls, pesticides, electrocardiogram electrode adhesives, bandages, dental bonding materials, printer inks, photographic developers, and copy paper.

Patients should avoid PTBP-containing waterproof adhesives used in leather goods. Frequent changes of socks and keeping footwear dry may help reduce dermatitis associated with exposure from footwear. In occupational settings, exposure to PTBP-containing plywood, laminated wood, fiberglass, mineral fiber products, sealants, coatings, and insulating materials should be minimized.

Methylchloroisothiazolinone/methylisothiazolinone

Methylchloroisothiazolinone (MCI)/methylisothiazolinone (MI) is a preservative mixture used in a variety of household and personal care products, including detergents, fabric softeners, wipes, coated paper products, soaps, body washes, shampoos, conditioners, toothpaste, and mouthwashes. MCI and/or MI may also be present in nail polish, cosmetic glitter adhesives, toy slime, paints, ultrasound gels, and printer inks [17,30-32]. In occupational settings, exposure may occur through paints, metalworking fluids, and adhesives.

In Korea, the United States, Canada, Europe, and other countries, the use of MI or MCI/MI mixtures is restricted; these restrictions include a concentration limit of 0.0015% in rinse-off products and prohibitions in certain other products, such as leave-on cosmetics. Toothpastes containing these preservatives have also been banned in Korea.

Budesonide

Budesonide is a group B steroid used topically. Patients with budesonide allergy should inform their healthcare providers and avoid medications containing budesonide when clinically appropriate (e.g., Pulmicort). Cross-reactions may occur with other corticosteroids, including desonide (DesOwen), hydrocortisone (LactiCare), triamcinolone, methylprednisolone (Advantan), prednisolone (Lidomex), and prednicarbate (Dermatop).

Colophonium (colophony, rosin)

Colophonium, also known as colophony or rosin, is an amber-colored resin obtained from pine trees as a residue of turpentine distillation. It is used in products such as crayons, wearable health devices, cosmetics, moisturizers, sunscreens, diapers, sanitary pads, rosin preparations used by musicians and athletes, printer inks, and coated paper products such as copy and photographic paper [33,34]. Medical sources include hydrocolloid dressings, adhesives used with glucose-monitoring devices and insulin pumps, medical tapes, and dental adhesives [15,35]. Colophonium or related resin components may also be encountered in chewing-gum bases and spices such as paprika, nutmeg, and cloves. Industrial uses include varnishes, cleaning products, adhesives, waxes, paints, and soldering materials.

Patients with colophonium allergy should avoid direct contact with sap or sawdust from coniferous trees. Cotton gloves may reduce contact when handling rosin-treated paper, whereas rubber or vinyl gloves may be needed when handling paints, varnishes, pine oil, and related materials. Cross-reactions may occur with wood tar, rosin esters, and substances derived from evergreen species.

Captan

Captan is a fungicide used as an agricultural pesticide. Occupational exposure may occur in farming and fruit production, particularly through contact with treated plants and fruit. Captan may also be present in some soaps and shampoos.

Lanolin (wool alcohol)

Lanolin, which is derived from sheep wool, is used as an emollient and ointment base in many cosmetic and pharmaceutical products. Potential sources include dishwashing detergents, shampoos, soaps, body washes, conditioners, cosmetics, cleansers, nail polish removers, moisturizers, hand creams, masks, and topical medications. Lanolin may also be present in printer inks, lambskin condoms, and industrial polishing products.

Imidazolidinyl urea (Germall 115)

Imidazolidinyl urea (Germall 115) is an antimicrobial preservative used in cosmetics and personal care products. It is a formaldehyde-releasing preservative, as are bronopol, dimethylol dimethyl hydantoin, diazolidinyl urea, and quaternium-15. Products that may contain imidazolidinyl urea include soaps, detergents, shampoos, conditioners, hair sprays, cleansers, exfoliating products, cosmetics, moisturizers, eye creams, perfumes, and deodorants. It has also been reported in ultrasound gels and topical medications [32]. Patients with imidazolidinyl urea allergy should inform their healthcare providers and check ingredient lists before using new products. Previously tolerated products may also trigger reactions if their formulations change.

Quaternium-15

Quaternium-15 is a formaldehyde-releasing preservative used in personal care products such as shampoos, body washes, cosmetics, cleansers, moisturizers, and nail hardeners. It may also be present in disposable masks, wrinkle-resistant fabrics, and electrocardiogram electrode adhesives.

Patients should review ingredient lists and select products that do not contain quaternium-15. Relevant occupational and environmental sources may include industrial oils, plywood, paints, waxes, cigarette smoke, exhaust fumes, and wood smoke.

2-Mercaptobenzothiazole

2-Mercaptobenzothiazole (MBT) is a rubber additive used in a variety of rubber products, including gloves, mats, bands, balloons, erasers, handle grips, electrical cords, earphones, makeup sponges, goggles, swimwear, wetsuits, brassieres, stockings, and shoes. Additional sources include stethoscopes, tokens, dental dams, condoms, elastic diaper edges, and photographic developers [36]. Occupational sources include tires, lubricants, adhesives, masks, tubing, and hoses.

For patients with MBT allergy, both natural and synthetic rubber products should be avoided. If contact cannot be avoided, covering the item with fabric, leather, or plastic may reduce direct skin exposure. Prolonged exposure to MBT may also be associated with sensitization to other rubber chemicals, including thiurams, carbamates, and other mercapto compounds.

Mercapto mix

Mercapto mix is a rubber additive containing N-cyclohexyl-2-benzothiazole sulfenamide, 2,2'-dibenzothiazyl disulfide, and morpholinyl mercaptobenzothiazole. These compounds may be used in the manufacture of rubber products such as gloves, mats, bands, balloons, erasers, handle grips, electrical cords, earphones, makeup sponges, goggles, swimwear, wetsuits, and shoes. Additional sources include stethoscopes, tourniquets, dental dams, and condoms. Occupational exposure may occur through tires, adhesives, masks, tubing, and hoses.

When relevant rubber products must be avoided, vinyl, plastic, leather, wood, or fabric alternatives may be used where appropriate. Prolonged exposure to rubber products may be associated with sensitization to other rubber chemicals, including thiurams, carbamates, and related mercapto compounds.

Clioquinol

Clioquinol is an antimicrobial agent with antibacterial, antifungal, and antiprotozoal activity. It has been used in medicated dressings and in topical and intestinal anti-infective labels before using topical creams, ointments, or vaginal preparations.

Occupational contact allergens

Hairdressers

Hairdressers with metal allergies should minimize direct contact with metallic tools such as scissors, combs, curling irons, hairpins, and hair clips [37]. Nickel release from metallic tools may be increased by exposure to chemicals used in salons. Latex gloves may permit more rapid penetration of allergens in permanent-wave solutions; therefore, vinyl or nitrile gloves may be preferable [48]. However, individuals allergic to rubber accelerators such as thiurams should exercise caution with rubber bands and may need to avoid latex or nitrile gloves in favor of vinyl gloves. Those with allergies to fragrances or preservatives, including parabens, formaldehyde, and MCI/MI, should avoid hair products containing the relevant allergens. Individuals with paraben allergy should also avoid paraben-containing waxes. Those allergic to PPD should avoid PPD-containing hair dyes and should be aware of potential exposure to cross-reacting dyes, including those in some surgical marking pens. Bleaching and permanent-wave products may also cause contact reactions [48].

Healthcare workers

Healthcare workers allergic to rubber accelerators such as thiurams should avoid rubber gloves (e.g., latex, nitrile, and neoprene) and use polyethylene or vinyl alternatives [49]. Those allergic to preservatives such as quaternium-15 should check hand sanitizers, soaps, and hand creams for relevant allergens. Healthcare workers with rubber accelerator allergy should avoid rubber-containing mask straps when clinically relevant. Those with formaldehyde allergy should consider potential exposure from disposable surgical masks, whereas individuals with nickel or cobalt allergy should consider potential metal exposure from N95 respirators. Patients with colophonium allergy should avoid relevant plasters, adhesive bandages, and hydrocolloid dressings. Individuals with thimerosal allergy should inform their healthcare providers before vaccination so that the formulation can be assessed without unnecessarily delaying immunization. Those allergic to PTBP should consider potential exposure from electrocardiogram electrodes and bispectral index sensors [48].

Dentists and dental hygienists

Dentists and dental hygienists with allergy to rubber accelerators such as thiurams should avoid rubber gloves (e.g., latex, nitrile, and neoprene) and use polyethylene or vinyl alternatives. Those with allergies to metals such as nickel, cobalt, or chromium should minimize direct exposure to metal-containing dental materials, including bridges, crowns, and dentures, as some allergens may penetrate gloves within minutes. Occupational allergic reactions may also occur in association with local anesthetic preparations, impression materials, mercury amalgam, dental cement, essential oils, and other substances. Because acrylic resins may cause airborne exposure, adequate ventilation should be maintained when these materials are handled. Exposure to formaldehyde during instrument sterilization should also be minimized.

Cooks

Cooks with metal allergies should minimize direct contact with metallic cookware and utensils when these items contain the relevant allergen. Individuals allergic to nickel, cobalt, or chromium should also consider the potential for exposure when handling ingredients such as legumes, whole grains, cabbage, tea, and cocoa. Those allergic to rubber accelerators such as thiurams should use gloves without the relevant accelerators; vinyl gloves may be an appropriate alternative to some latex or nitrile gloves. Individuals allergic to Balsam of Peru or fragrance mixes may need to avoid relevant flavorings and spices, including vanilla extract and cinnamon. Certain preservatives, including benzoin, have also been reported to cause airborne contact urticaria without direct skin contact.

Guidance on selecting allergen-free alternatives

Patch testing

Repeated open application tests may help assess suspected products in patients with ACD.

Product labeling

Consider products labeled "hypoallergenic," "fragrance-free," or "sensitive skin" to reduce the risk of allergic reactions.

Ingredient awareness

Patients should become familiar with their allergens and alternative ingredient names to reduce inadvertent exposure.

Natural alternatives

Natural and organic products, specifically those containing minimal additives and preservatives, may be considered to lower

the risk of allergic reactions.

Healthcare consultation

Dermatologists or allergists can provide individualized guidance regarding allergen avoidance and treatment.

Discussion

Interpretation

This review updates information on the KSS by incorporating emerging or newly recognized sources of allergen exposure, including electronic devices, newer cosmetic products, and personal protective equipment. Because the existing patient information has not been substantially revised for more than 2 decades, these updates may help align allergen-avoidance guidance with contemporary exposures and may also inform future evaluation of changing exposure patterns in ACD. Interpretation of patch test results should distinguish among patch test positivity, clinical relevance, and current relevance. A positive reaction generally indicates sensitization to the tested allergen; clinical relevance considers whether that sensitization is related to a patient's dermatitis, whereas current relevance indicates whether the allergen contributes to the present episode. Because some allergens may produce positive reactions that have only historical or limited clinical relevance, avoidance recommendations should be based on the clinical significance of the reaction rather than patch test positivity alone.

Limitations

First, the narrative review design and restriction to English-language literature may have introduced selection bias and excluded relevant regional evidence. Second, empirical epidemiological data regarding the prevalence and clinical relevance of these emerging sources specifically in the Korean population remain limited.

Implications

Dermatologists can use these updated education sheets to support patient allergen avoidance. Furthermore, this review highlights the need for a formal revision of the KSS by Korean dermatological societies and for future prospective cohort studies to evaluate sensitization rates to these emerging environmental exposures.

Conclusion

Providing patients with comprehensive and accessible information is essential for managing ACD. Understanding specific allergens and potential cross-reactors may help patients identify clinically relevant exposures and reduce inadvertent contact and subsequent reactions.

Ultimately, the goal is to promote a proactive approach to allergen management. Continued education and technological tools may help patients make more informed decisions about allergen avoidance. Strategies such as allergy passes, smartphone applications, and legal protections may also be beneficial in supporting allergen avoidance [1].

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Authors' contribution

Conceptualization: HYC. Data curation: JC. Methodology/formal analysis/validation: JC, HYC. Project administration: HYC. Writing–original draft: JC. Writing–review & editing: JC, HYC.

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Supplementary materials

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Supplement 1. Korean Standard Series allergen sheets in Korean.

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