DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service

National Institute for Occupational
Safety and Health
1090 Tusculum Avenue
Cincinnati OH 45226-1998

HHE 2017-0034 Appendix

The information in this Appendix: (1) presents details related to the background, methods, findings, and literature review for this Health Hazard Evaluation (HHE); and (2) supplements the discussion, conclusions, and recommendations in the body of the primary letter.

BACKGROUND

As of 2016 American Airlines (AA) employed 120,000 people. Of these employees, the Association of Professional Flight Attendants (APFA) represents about 26,000 "mainline" flight attendants who work directly for AA. Other unions, including the Association of Flight Attendants (AFA), represent about 5000 flight attendants who work for regional carriers with which AA contracts services. For the purpose of this report, these flight attendants are not considered "mainline" AA employees. AA rolled out a new uniform for all of to their 70,000 customer-facing employees, which included "mainline" and regional flight attendants. This evaluation focused on the "mainline" AA flight attendants who are represented by APFA.

Information about AA Uniforms

According to the negotiated contract between AA and APFA, flight attendants must wear the prescribed uniform at all times when on duty. The single exception is when flight attendants travel to their crew base or another city at the company's request. In February 2015, Twin Hill, a subsidiary of Tailored Brands, was contracted by AA to supply uniforms to their 70,000 employees. Between January and April 2016, Twin Hill representatives traveled to multiple airport locations to allow AA employees to try on garments and place orders. Employees were offered the option of ordering non-wool (cotton/synthetic blend or all-cotton) uniform components prior to the complete roll out. Some uniform orders were shipped from Twin Hill to AA employees beginning in May 2016. The first day employees wore the uniforms on the job was in late September 2016. The new uniform consisted of combinations of garments made of wool blend fabric (53% wool, 45% polyester, 2% spandex) and non-wool blend (63% polyester, 33% viscose, 4% elastane). Garment linings were made of 94% polyester, 6% spandex except for two garments with linings made of 100% polyester.

According to the employee requestors and APFA representatives, employees began reporting symptoms they believed to be related to touching or wearing the Twin Hill uniform shortly after uniforms were delivered beginning in May 2016. APFA began a webpage on August 11, 2016 which solicited reports of health effects potentially related to the new uniforms.

Pre-distribution Wear Tests

Wear test information was provided by Twin Hill and AA. From mid-December 2014 to mid-January 2015, 500 AA employees participated in a wear test with new uniforms manufactured by Twin Hill but designed by a different firm to provide feedback. After negative feedback on the

design, AA terminated the contract with this first firm. From late September 2015 until late October 2015, a second wear test with uniforms designed by Twin Hill was conducted. The wear test survey focused on fit, function, construction, and style. Health symptom questions were not included. Seventy-eight AA employees wear-tested the uniforms including 21 pilots, 35 flight attendants, 14 customer service, and 8 premium service employees. Based on the survey results provided, AA male Flight Service employees had no complaints. Female Flight Service employees gave feedback on the fit and style of the serving garment. Both male and female pilots gave feedback on the thickness of the shirt fabric and on preference for the single-breasted jacket. AA was to explore the possibility of offering additional shirt fabrication mixes at or post rollout, and decided to move forward with the single-breasted jacket design. After the second wear test results, AA instructed Twin Hill to proceed with manufacturing the new uniforms.

Uniform Alternatives

In October 2016, AA offered an alternative to wearing the new uniform: employees could continue to wear their previous uniform instead of the new uniform. During this month, AA offered a second uniform alternative: employees were allowed to purchase look-alike replacement shirts and slacks from retail stores and be reimbursed by the company. Also in October 2016, AA established a call center as a resource for employees with concerns about the uniform to review uniform options and alternatives. In March 2017, AA offered a third uniform alternative for Flight Service (including flight attendants), Customer Service, and Premium Customer Service employees: an "off-the-shelf" uniform supplied by a different manufacturer. These uniforms included a 100% polyester jacket (with pant/skirt combination), 100% cotton shirts, and an acrylic/cotton blend sweater. These garments were available for order at the end of March 2017 with limited availability at that time, and with broader availability in the fall of 2017.

Supply chain of garments

Twin Hill provided a timeline of the AA Uniform Program and an overview of the Twin Hill supply chain, as it pertains to the AA program. They also provided supply chain information for all 260 types of garments produced for American Airline uniforms. The supply chain included the name of the garment piece, employee work group who it was available to, color, factory (that used the fabric to make uniform pieces), fabric composition, mill (that made the fabric), and if the mill was OEKO-TEX® certified.

According to Twin Hill records, the Twin Hill garments of concern were created, shipped, and handled per standard procedures, described below. Fabrics are produced at one of 14 independent, international fabric mills. Of the 14 mills, 12 have OEKO-TEX® Standard 100 [OEKO-TEX, 2018] certification (nine in China, one in Bulgaria, one in United Kingdom, one in France). This is an independent certification system for finished fabrics, designed to certify the absence of banned and harmful substances, to limit the concentrations of potentially harmful substances, and to deliver assurance of product safety. The remaining two mills (one in South Korea and one in Italy) self-certified as to their conformity with the absence of restricted chemicals and European Chemicals Agency (ECHA) substances of very high concern. OEKO-TEX® certificates for the 12 mills and the self-certification for the South Korean and Italian

mills were provided by Twin Hill. Most of the OEKO-TEX® certificates stated that the fabrics manufactured in the mill, including the dyes and/or finishes used in the production of the fabric, are tested for substances according to OEKO-TEX® Standard 100. Dyes listed on the certificate include acid, metal complex, reactive, basic, and/or disperse dyes in different colors. Finishes listed on the certificate include water-repellent Teflon treatment, softening, antistatic, wrinkle-free, and wicking agents, as well as water-proof, oil-proof, and stain-proof agents.

After fabric inspection, fabrics are shipped from the fabric mills to separate independent factories to assemble garments. Twin Hill uses 12 factories: three in China, three in Vietnam, two in Bangladesh, two in Sri Lanka, one in Indonesia, and one in Hungary. Once assembled, the uniforms are packaged by the factories (without the use or addition of any chemicals) in plastic bags designed to be laid flat or in hanging bags, depending on the garment type. All plastic bags are sealed but contain at least one "breathing hole." These bags are then placed in sealed containers, and shipped to the U.S. from the factories according to the Customs-Trade Partnership Against Terrorism standards developed by U.S. Customs and Border Protection. The containers must remain sealed during transportation to their seaport (California) or airport (Dallas/Ft. Worth International Airport) destination unless opened and resealed by U.S. Customs agents. The containers are checked by U.S. Customs agents and then delivered by train or truck to the Twin Hill Distribution Center in Houston, Texas, where they are opened. Twin Hill employees organize the uniforms by size and style, scan the garment shipments into their tracking system and perform inspections and spot checks of individual garments. The garments are then stored until an order is received. Twin Hill reported that no chemicals are applied during the handling or storage processes. Twin Hill stated that, generally, the uniforms are shipped directly to AA employees after being placed inside boxes supplied by Houston Foam Plastics. Twin Hill reported it had not received any report or other information suggesting any contamination of the fabric mills, including structural damage, natural phenomenon, or other potentially compromising circumstances.

Textile Chemicals, Regulations, and Certifications

Textile finishing resins are used to reduce shrinking and wrinkling and to improve quality, texture, and appearance of the textile. Historically, exposure to formaldehyde from textile resins has contributed to skin problems. However, in recent years, formaldehyde concentrations in resins have been greatly reduced in response to these concerns and international regulations or guidelines that have been developed [GAO 2010; DeGroot and Maibach 2010]. Studies evaluating textile chemicals and finishing resins represent the bulk of studies done on textiles and dermatitis. Other types of textile treatments, such as non-dispersion dyes, have not been well characterized in the scientific literature.

The United States has not developed requirements pertaining to the chemical or metal contents of adult apparel. The OEKO-TEX® Standard 100, a voluntary standard placing limitations on certain chemical content in textiles, was developed by the International OEKO-TEX® Association in 1992. The chemicals in the OEKO-TEX® standard are partially based on the list of substances of very high concern established by the European Union's Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) program. The REACH

program issues an annual list of substances of very high concern. ECHA regulates how these chemicals can be used. As of 2017, 173 substances were included on the ECHA list of substances of very high concern.

In 2009, the American Apparel and Footwear Association (AAFA) published their Restricted Substance List, which has similar standards to the OEKO-TEX® 100 standards, and encouraged its members to voluntarily follow these textile parameters [DeGroot and Maibach 2010; Reich and Warshaw 2010]. Some individual companies, such as H&M, also publish the limit values and internal standards they apply to their finished products [H&M 2017].

GENERAL INFORMATION CONCERNING ILLNESS CLUSTERS AND METHODS

Diseases and symptoms often appear to occur in clusters, which scientists define as an unusual concentration of cases in a defined area or time [CDC 1990]. The cases may have a common cause or may be the coincidental occurrence of unrelated causes. The number of cases may seem high, particularly among the group of people who have something in common with the cases, such as working in similar conditions.

In investigating a perceived excess of symptoms among employees of the same workplace, we begin by gathering data on workers with reported symptoms. To assess whether symptoms among employees could be related to occupational exposures, we consider the type of symptoms, the number of employees with symptoms, and the likelihood of exposure to agents potentially causing symptoms. These issues are discussed below as they relate to our evaluation.

We collected information on uniform symptoms from AA employees through telephone calls and emails. We held conference calls with representatives from AA, APFA, and Twin Hill Corporation to discuss the HHE request and ask for information pertaining to the request. AA provided results from the second wear test conducted prior to uniform rollout, Occupational Safety and Health Administration (OSHA) Form 300 Logs of Work-Related Injuries and Illnesses for years 2015, 2016, and 2017, OSHA 300A summary sheets for years 2015 and 2016, and a summary of workers' compensation claims related to uniforms filed from uniform roll out through July 28, 2017.

APFA provided a de-identified database of employee symptom reports from August 11, 2016, through May 2, 2017, and updated summary information from this database.

In order to learn more about whether or not a specific agent(s) was associated with the reported symptoms in employees, we reviewed fabric testing results from laboratories that conducted analyses on behalf of AA, Twin Hill, and APFA. We reviewed testing results from Hohenstein Textile Testing Institute (contracted by APFA), Intertek Chemicals and Materials, and Intertek Scientific and Regulatory Consultancy (both contracted by AA), and TÜV Rhineland (contracted by Twin Hill) concerning chemicals to which uniform wearers may be exposed.

RESULTS

Review of AA OSHA Logs, Workers' Compensation Claims, and APFA Symptom Database Results

There were no skin disorder entries documented on the 2015 OSHA logs. In 2016, each hub location documented at least one skin entry related to the uniform on their OSHA log, except for JFK, which had only one entry total that year. Total OSHA log entries (Appendix Table 1) in 2016 for all hubs included 87 skin disorder entries (8% of the total entries), of which 83 (95 % of 87) were reported to be related to the uniform. All but two of the skin entries reported to be related to uniforms in 2016 were reported on or after September 9, 2016. The other two entries were reported on June 28, 2016 and August 8, 2016. In the first four months of 2017, 13 skin disorder entries were reported; all reported to be related to the uniform. Respiratory conditions reported to be related to the uniform were entered in 2016 (n = 27) and 2017 (n = 18). Table 1 shows the number of injury and illness entries, by illness and injury category, for years 2015, 2016, and part of 2017.

Appendix Table 1. Number of OSHA 300 injury and illness log entries for AA mainline flight attendants for years 2015, 2016, and January 1, 2017, through April 30, 2017; by injury and illness type

Type of entries	Number of entries		
	2015	2016	January through April 2017
Total OSHA 300 Log entries:	715	1,129	370
Sprain/strain	409	541	182
Laceration/contusion/puncture	125	249	93
Hearing loss/ear pressure	36	56	17
Musculoskeletal disorders	39	23	1
Fractures	29	42	13
Concussions	13	20	4
Skin disorders	**0**	**87**	**13**
- **From uniform**	**0**	**83**	**13**
Respiratory conditions	14	68	39
- **From uniform**	**0**	**27**	**18**
Eye disorders, irritation	5	9	2
- From uniform	0	0	1
Head/face reaction to uniform	0	0	2
Other	45	34	4
Total AA mainline flight attendants	24,944	25,674	26,167

AA provided a table of workers' compensation claims related to the uniforms filed through July 28, 2017 (Appendix Table 2). Among a reported 27,100 flight attendants, 592 claims were filed. No information was available concerning any further evaluation of these claims.

Appendix Table 2. Number of AA worker compensation claims related to uniforms, filed through July 28, 2017, by job type and symptom reported in claim.

Job Type	Total claims filed (%)*	Skin-related only	Other symptoms only†	Both skin and other symptoms
Flight attendants (n~27,100)	592 (2.1)	196	192	204
Pilots (n~16,400)	10 (0.06)	6	3	1
Customer service (n~13,800)	125 (0.9)	61	22	42
Total of all job types (n~57,300)	727 (1.3)	263	217	247

*Percent of employees in job type
†This includes respiratory, eye, nose, and throat symptoms, headaches, and other non-skin symptoms.

We reviewed the APFA de-identified database of employee uniform symptom reports from August 11, 2016, through May 2, 2017. The AFPA database was a compilation of reports received from the AFPA webpage initiated on August 11. The APFA database included multiple symptoms and illnesses that were reported to be related to the uniform. Reported skin problems included hives, rashes, blistering, itching, discoloration, bruising, open sores, sunburn-like rash, chemical-like rash, and swelling. Reported respiratory problems included shortness of breath, wheezing, cough, congestion, asthma, sore throat, sinusitis, and coughing up blood. Reported eye problems included irritation, excessive tearing, redness, infections, styes, conjunctivitis, swelling, bloodshot eyes, subconjunctival hemorrhage, spasms, and twitching. Reported musculoskeletal problems included joint pain, muscle aches and spasms, fibromyalgia, muscle fatigue, and muscle atrophy. Reported gastrointestinal problems included stomach discomfort or irritation, nausea, diarrhea, and vomiting. Reported neurological problems included insomnia, headaches/migraines, cognitive issues, and depression. Other reported symptoms or signs reported as related to the uniform included thyroid issues, weight gain or loss, irregular menstrual cycles, sleep disturbances, night sweats, excessive hair loss, palpitations, increased or decreased blood pressure, swollen lymph nodes, recurring sinus and bronchial infections, laryngitis, overall edema, fatigue and exhaustion. Skin symptoms and respiratory symptoms were the most commonly reported symptoms.

The database included 3,686 reports of symptoms thought to be due to the new uniform; some employees reported more than one symptom. Of the 3,686 symptom reports, 796 reports stated medical attention was sought. Of these 796 reports, 511 were related to skin symptoms, 411 were related to respiratory symptoms, 165 were related to eye symptoms, and 204 were related to both skin and respiratory symptoms. Several employees reported more than one type of symptom. Symptoms reported to occur while not wearing the uniform, but in the proximity of others wearing the new uniform, were reported 47 times.

The APFA database included a comments section. Comments from employees who reported symptoms and sought medical attention were reviewed. Self-described rashes were reported in multiple locations on the body. However, several of the employees reported their rashes were in typical locations where textile dermatitis is commonly located, including in and around the axillae (armpits), front of thighs, neck and back, and waist. Many flight attendants reported skin itching and burning within a few seconds to a few hours of wearing the uniform. Also, there were many reports of itching and irritation in the location where the lining or undergarment was not covering the skin. Some employees noted that the sweaters caused itchy, red skin irritation within a few minutes of putting on the skin ("like glass shards," "cactus needles," "fiberglass"). Some employees reported that they had worn wool many times before and never had any problems, but that the sweater fabric was very irritating to them. Employees also reported that pants, dresses, and scarves were made from scratchy fabric. Several flight attendants reported seeing a dermatologist. To our knowledge, no employees were skin patch tested with pieces of uniform.

The records of reported symptoms that we reviewed showed that neither one specific uniform piece nor a group of uniform pieces with the same fabric content were consistently linked to symptoms. As of September 5, 2017, we have been updated that the APFA had received 4,638 symptom reports from 3,962 individual flight attendants.

Individual communication with AA flight attendants

We spoke with or communicated by email with 50 AA employees who contacted us. Of the 50 employees, 28 were flight attendants, 11 were customer service employees, one was a pilot, and ten did not give their job title. Of the 50 employees, 29 reported skin irritation, 13 reported respiratory symptoms, and nine reported eye symptoms after wearing the uniform. Some of the employees reported fatigue, flu-like body aches, and changes in thyroid function and menstrual patterns.

Eleven reported seeing a healthcare provider because of symptoms they believed were caused by wearing the uniform. We received medical records for two of the eleven employees and photos of physician office notes for an additional seven employees; most of the medical documentation we received was incomplete concerning occupational health issues. Three employees reported being diagnosed with multiple chemical sensitivity disorder; two provided physician notes confirming this diagnosis. Six reported a diagnosis of contact dermatitis; four provided physician notes confirming this diagnosis. Four of the six with contact dermatitis underwent skin patch testing. Of these, one provided physician notes stating the employee was allergic to a

preservative which had been found in the uniform, but also found in many cosmetics and hygiene products; one provided physician notes stating the employee was allergic to chemicals in her uniform but no specific chemicals were listed, and two reported negative test results. No employees reported being skin patch tested to pieces of the uniform.

Review of Laboratory Testing

Hohenstein garment testing
Hohenstein Textile Testing Institute was contracted by the APFA to conduct analyses of several of the uniform pieces. The laboratory tested the pieces in October and November 2016 according to the parameters set forth by OEKO-TEX® Standard 100 and compared those results to the limits for product class II, where skin contact is expected.

Extractions from the 12 garments tested by Hohenstein were tested for pH, free and partially releasable formaldehyde, 25 banned azo colorants and selected aryl amines, 36 allergenic or carcinogenic colorants, nine heavy metals, nonylphenol, octylphenol, certain alkylphenolethoxylates, five chlorinated phenols, orthophenylphenol, and total pesticides. Samples from the 12 garments were digested and tested for total cadmium and lead.

The pH of the garments ranged from 5.9 to 6.7 within the OEKO-TEX® Standard 100 acceptable range of 4.0 to 7.5. Most chemicals were not detected in the samples. Some of the garments contained detectable levels of the following 12 substances: carbaryl (two garments), cadmium (two garments), captafol (one garment), chromium (three garments), formaldehyde (two garments), monochlorophenols (one garment), nickel (three garments), nonylphenol (one garment), nonylphenolethoxylates (two garments), pentachlorophenyl (two garments), tetrachlorophenol (two garments), and trichlorophenol (one garments). The concentration of one substance, cadmium (0.14 mg/kg), exceeded the OEKO-TEX® Standard 100 limit (0.1 mg/kg) in one uniform item; the remaining concentrations were below their respective limits within OEKO-TEX® Standard 100.

TÜV Rhineland garment testing
Twin Hill contracted TÜV Rhineland, an independent testing laboratory, to analyze the new uniforms for chemicals to which uniform wearers may be exposed. The laboratory tested the samples for (1) chemicals known or suspected to impact human health, (2) substances reported to be sensitizers in case reports or scientific literature and (3) agents reported by media outlets to be in the uniforms. The samples were tested for chemicals included in the list of "Substances of Very High Concern" as developed by ECHA under the REACH program and substances included in OEKO-TEX® Standard 100. Twin Hill contracted Ramboll Environ to summarize the testing data and evaluate the connection between the new uniforms and the reported symptoms. Ramboll Environ also reviewed the product list of dyes, finishing agents, and similar additives used to impart certain characteristics to textiles and which were offered on some of the Twin Hill contracted fabric mills' OEKO-TEX® certificates. The evaluations were conducted by toxicologists accredited by the American Board of Toxicology.

TÜV Rhineland measured uniform extractions for pH, formaldehyde, chlorinated phenols, disperse dyes, and metals. They also analyzed the samples for the chemicals on the ECHA 2016 and 2017 Lists of Substances of Very High Concern. In order to be included on this list, a chemical must meet one or more of the following criteria: (1) Class 1 or 2 carcinogen, mutagen, or reproductive toxin, (2) persistent, bio-accumulative and toxic, and/or (3) another cause for concern (such as endocrine disruption). None of the 173 chemicals on these lists were measured at or above the screening limit of 0.1% (1000 ppm) or higher in the tested garments. However, these criteria do not necessarily speak to the allergenic or sensitizing capacity of the chemicals on the list.

The pH of the four garments tested ranged 4.9 to 6.4, within the OEKO-TEX® Standard 100 acceptable range. TÜV Rhineland sampled for nine extractable metals in 28 garment samples. Levels of extractable metals were found in three garments samples above their respective reporting limit: lead (two garments), chromium (one garment) and copper (two garments). An extracted chlorophenol was found at the reporting limit of 0.1 mg/kg in one sample. This is below the OEKO-TEX® limit of 0.5 mg/kg.

TÜV Rhineland sampled for 33 disperse dyes in 26 garment samples. One disperse dye was found in one garment above the reporting limit of 15 ppm. Disperse brown 1 was detected in the sample at 30 ppm. The OEKOTEX limit is 50 ppm. None of the substances reported exceeded their respective OEKO-TEX® limit value.

In response to concern voiced by AA employees, TÜV Rhineland included benzyl benzoate in their analyses. It was not detected in ten fabric samples at or above the reporting limit of 50 mg/kg. Benzyl benzoate is a common ingredient in personal care products, like some deodorants, and would not be expected to cause widespread, novel reactions for individuals who are not already sensitive to the compound. An ingredient review panel suggested that exposure up to 5000 ppm could generally be considered safe for human exposure [Cosmetic ingredient review (CIR) 2011].

Intertek garment testing
Intertek Chemicals and Materials, contracted by AA, screened a solvent extraction from garments for volatile and semi-volatile compounds, rather than measuring specific chemicals. The concentrations reported by Intertek were that within the extraction solvent. Depending on the extraction efficiency, the chemical content of the garment may be higher. Most established chemical limits in textiles are based on extraction concentrations with a minority based on digestion concentrations. They also digested uniform pieces to analyze for metal content, rather than analyzing an extraction. Their analyses included new uniform pieces, legacy uniform pieces, and garments from retail stores.

The formaldehyde levels across all of the new uniform pieces sampled ranged from below the limit of detection to 32 ppm. Intertek Chemicals and Materials assessed formaldehyde content using EPA method 8315A [EPA 1996]. Formaldehyde concentrations in 13 samples from four returned AA uniform pieces ranged 0.60 to 7.0 ppm. All measurements were below 75 ppm, the

limit established for clothing by OEKO-TEX® Standard 100. These are the most conservative standards currently in use for formaldehyde in clothing.

Intertek Chemicals and Materials screened several AA garments for volatile and non-volatile chemicals. Garment samples were also digested and analyzed for total content of arsenic, cobalt, lead, chromium and antimony. Intertek Scientific and Regulatory Consultancy provided a technical opinion on the results of these analyses as to their irritation and sensitization potential. They cross-referenced the chemicals and metals found in the garments to twenty documents or databases that contain information about dermal or respiratory sensitizers. A subset of these sources included: the Cosmetic Ingredient Review (CIR) documents, ECHA Registered Substances [Database], Consumer Product Safety Commission Part 1500 hazardous substances and articles, Agency for Toxic Substances and Disease Registry toxicological profiles, and European Commission Scientific Committee on Cosmetic Products and Non-Food Products Intended for Consumers opinion statements.

The end result was a list of potentially irritating and/or skin sensitizing agents found in extractions from garments from unworn AA uniforms, worn AA uniforms, legacy US Airways uniforms and retail clothing. The list comprised 24 potentially skin sensitizing agents and 44 non-metallic potentially irritating agents. Twelve potential skin sensitizers were found in the unworn AA uniforms, and seven were identified in returned AA uniforms, which were worn and unworn. The garments analyzed from the new AA uniforms contained a wider variety of potential skin sensitizing compounds than the legacy US airways uniforms, returned AA uniforms, and unworn retail items. However, most of the potential sensitizers were found in a small minority of the pieces sampled. For example, eight of the 12 potential sensitizers were found in 1 of the 55 of the new uniform garments tested. Three metals with sensitizing potential (antimony, chromium, and cobalt) were identified in a majority of the samples in both categories (new and returned), as well as in US Airways legacy uniforms and retail garments. Intertek Chemicals and Materials also detected methylene diphenyl diisocyanate in an extraction from one of the new uniform garments tested. Intertek Chemicals and Materials tested up to 4 locations in a single uniform components. Concentrations of individual metals and chemicals were frequently inconsistent within individual single garments.

Intertek Chemicals and Materials looked specifically for benzyl benzoate, which was detected in US Airways legacy garments and in returned and unworn AA uniforms, since it had been highlighted as a potential cause of the symptoms. Intertek found benzyl benzoate in the legacy US Airways uniform as well as the new AA uniforms [Intertek 2016]. The International Fragrance Association has categorized benzyl benzoate as a weak skin sensitizer [IFRA 2007]. Related to this, a review from 1999 reported that one of 619 people tested exhibited allergy to a 20,000 ppm benzyl benzoate mixture, while in other studies, small fractions of allergy to fragrances were due to allergy to benzyl benzoate [European Union 1999].

Overall, Intertek Scientific and Regulatory Consultancy identified several potentially irritating or sensitizing chemicals in the new and returned AA garments, but the chemical compounds were not found consistently across all garments thought to be related to dermal reactions. For most of

the identified sensitizing agents, there is little data available in the scientific literature or within regulatory guidelines about the amount of dermal exposure necessary to cause sensitization or to cause a reaction in a sensitized individual. This lack of data made evaluating the potential of sensitization for most chemicals and metals difficult.

Some chemicals detected by Intertek Chemicals and Materials were not uniquely identified and were labeled as "unknowns" or were listed as part of a larger class, such as "aromatics." These cannot be evaluated for irritation or sensitization potential since they are not identifiable. According to Intertek Scientific and Regulatory Consultancy representatives, the "unknowns" in each sample were not compared across samples to determine if each unique "unknown" peak was found in more than one sample and were not compared to fabric treatments, resins, dyes, or other additives used in the textile factories as listed on the safety data sheets.

REVIEW OF LITERATURE

Skin symptoms are relatively common in the working population. Data from the 2010 National Health Interview Survey showed that the overall prevalence of dermatitis reported among 17,524 current/recent workers in the previous 12 months was 9.8%, with 5.6% of these cases being attributed to work by health professionals [Luckhaupt et al. 2013]. In the United States, a recent study found the prevalence of dermatitis in adults could be as high as 10%, while the prevalence of atopic dermatitis, which has an immunological/allergic/genetic component, could be 6% of US adults [Hanifin et al. 2007]. In 2015, Bureau of Labor Statistics (BLS) data showed an overall annual incidence rate of 2.3 cases of skin disorders per 10,000 workers and 1.3 cases of respiratory conditions per 10,000 workers [BLS 2017]. The numbers and rates in the BLS and NHIS surveys are not directly comparable because they rely on different information sources with different ascertainment methods and different case definitions. Additionally, because of BLS survey limitations, it has been estimated that the number of actual occupational skin diseases may be 10 to 50 times higher than that reported by the BLS (Mathias 1985).

Environmental stressors, including temperature, humidity, pressure, noise, vibration, and time-zone shifts, have been associated with the health and comfort complaints among flight attendants [Nagda and Koontz 2003]. Eye; ear, nose, throat; and respiratory symptoms are common among flight attendants. Studies of flight attendants and airline cabin crew found significantly higher rates of self-reported eye (10%–12%), nose (14%–16%), throat (7.5%), fatigue (18%), and hand skin symptoms (11%) when compared to other working women or to office workers [Whelan et al. 2003; Lindgren et al. 2002]. In addition, the self-reported prevalence of ever-diagnosed asthma was 8.2% and of current physician diagnosed asthma was 4.9% [Whelan et al. 2003]. Several other studies have also reported eye and respiratory symptoms among flight attendants [De Ree et al. 2000; Lee et al. 2000; Lindgren et al. 2000].

Possible causes of symptoms reported by the flight attendants include the cabin environment itself (e.g., cabin pressure and relative humidity), contaminants in the cabin air (e.g., ozone, pesticides, constituents of engine lubricating oils, and hydraulic fluids), and physiologic stressors

(e.g, fatigue, cramped space, and disrupted circadian rhythms) [National Research Council 2001]. A recent study of 579 flight attendants found that sinonasal symptoms were associated with increasing number of working days per month and the number of international trips per month [Shargorodsky et al. 2016]. Respiratory symptoms can be associated with a multitude of other respiratory conditions, most common of which are allergic rhinitis and viral upper respiratory infections.

In 2015, the Swedish Chemicals Agency evaluated chemicals in textiles for risk to human health (and the environment) [Swedish Chemicals Agency 2015]. They found that about 10% of the identified 2,400 textile-related substances were considered to be of potential risk to human health and are expected to be present in the final garment at relatively high concentrations, including azo dyes and fragrance. They concluded that there are few scientific publications concerning harmful effects from exposures of hazardous substances in textile articles. The European Commission DG Enterprise and Industry contracted a consultant to evaluate the link between potentially sensitizing chemicals in textiles and allergic reactions among wearers. They surmised that dyes, finishing resins, and other additives can cause allergic reactions, but concluded that determining prevalence is difficult to determine due to lack of data [RPS Advies- EN Ingenieursbureau BV 2013].

Laboratory analyses showed measureable amounts of known irritants and sensitizers in a subset of uniform pieces. There is evidence in the literature that subthreshold concentrations of irritants can have an additive effect on the skin [Tur et al. 1995]. For example, if the skin is exposed to only one of these irritants, no visible changes are seen, but if exposed to several, the skin may develop an irritant response. One study noted that it is currently difficult to detect newer textile allergens because chemicals used in textiles are not always declared [Lisi et al 2014]. A review article on textile formaldehyde releasing finishes stated that the amounts of free formaldehyde in textiles has decreased drastically in recent years and are generally low [GAO report 2010; DeGroot and Maibach 2010]. However, if cured incorrectly (not heated to a certain temperature for a specific length of time), the finishing chemicals may not bind to the fabric fibers as they should and in certain conditions such as sweating, high heat, and high humidity, the chemicals may leach out [DeGroot and Maibach 2010]. Although the use of textile resins with lower formaldehyde release has resulted in a decrease in the occurrence of formaldehyde-associated textile allergic contact dermatitis, it is still commonly seen with highly finished garments such as uniforms [Mobolaji-Lawal and Nedorost 2015]. The concentration at which each textile chemical causes sensitization has not been established for most chemicals, even for known dermal sensitizers. The process of establishing such values would have to take into account (1) the environment in which individuals are exposed to the textiles containing the chemical, (2) the potency and exposure frequency of the chemical allergen, and (3) ranges of susceptibility to sensitization within the population [Kimber et al. 2012].

The prevalence of textile contact dermatitis in developed countries appears to be increasing [Lisi et al. 2014; Lazarov 2004]. Some think that textile contact dermatitis is underestimated because of the sometimes atypical clinical presentation and the few textile dyes and finishing chemicals included in standard patch test series. Textile dermatitis is hard to predict because of several

factors including both individual and environmental factors. Individual factors include susceptibility to skin sensitization, immune function, the health of the skin barrier, and the capacity of absorption and reaction among individuals [Zhong et al. 2006; Kimber et al. 2012]. Those with a history of eczema or atopic dermatitis have an increased risk of developing allergic contact dermatitis. Environmental factors include exposure to irritant chemicals or physically irritating fibers and high temperatures and humidity causing increased sweating and leaching of chemicals out of fabrics resulting in increased skin exposure to chemicals.

Clothing dermatitis generally occurs in areas where clothing fits snugly, and the lesions are sometimes symmetrical [Rietschel et al. 2008]. Friction, warmth, and moisture tend to increase the appearance of clothing dermatitis. The clinical pattern is generally described as affecting the neck, major skin folds, and inner thighs. The areas protected by underclothing or the lining of a skirt or pants are often free of symptoms [Le Coz 2011]. Dermatitis from blouses and dresses typically involves the back. In addition, dress dermatitis affects the neck, elbows, and axillae (armpit), and can involve the forearms and wrists. Dermatitis from jackets affects the back of the hands, wrists, and forearms. Dermatitis from trousers occurs on the thighs and lower legs and on the back of the knees. Dermatitis from socks affects the feet and lower legs. Dermatitis from stockings or tights affects the lower legs, top of the feet and toes, and can also involve the back of the knees [Le Coz 2011].

One study concerning “sensitive skin” found that about 40% of the population reported having sensitive skin, defined as perceiving stinging, burning, pruritus, and tightness following various environmental stimuli [Draelos 1997]. Individuals with sensitive skin were found to have one or more of the following features: 1) heightened neurosensory input, 2) enhanced immune responsiveness, and/or 3) diminished skin barrier function such as a thinner stratum corneum or imbalance of lipid compounds in this skin layer [Berardesca 2017; Draelos 1997]. Those with sensitive skin may have an increased tendency for reacting to physical and chemical irritants touching their skin.

Skin patch testing is useful in determining whether someone has allergic contact dermatitis; however, there are limitations. There are a limited number of allergens that are included in skin patch test kits, including the specific series that includes textile allergens. If an individual is not tested to the pertinent allergen, no reactions are noted on evaluation and the individual might be erroneously considered to not have skin allergy. Patch testing with actual pieces of the uniform may be a better way of detecting allergic contact dermatitis. However, results may be falsely negative since the conditions that elicit leaching of dyes and resins from the fabric, such as sweating and friction, may not be the same when placing a piece of the textile on the skin of the back [Mobolaji-Lawal and Nedorost 2015].

Persistent postoccupational dermatitis (PPOD) can occur following allergic or irritant contact dermatitis. PPOD begins as a clear-cut occupational contact dermatitis. It initially gets better when removed from exposure, but with time, the capacity for resolution is lost and persistent dermatitis develops. Predictive factors for PPOD include duration of disease, inability to avoid causative agents, and age [Meding et al. 2005].

Many skin disorders, including contact dermatitis, have been shown to have a significant impact on quality of life [Lan et al. 2008; Fowler et al. 2006; Cvetkovski et al. 2005; Kadyk et al. 2003]. Rapid identification and treatment of contact dermatitis is important in preventing longer-term symptoms.

There is little information reported in the literature about health effects that may develop from skin exposure to textile chemicals, other than contact dermatitis. There is some evidence in the literature that certain chemical allergens (*e.g.*, isocyanates and beryllium) when encountered on the skin may have the potential to cause sensitization of the respiratory tract [Redlich 2010; Kimber 1996]. These findings suggest that there may be other chemicals that can be absorbed through the skin, react systemically, and lead to respiratory sensitization. A study by Elberling, et al. found a statistically significant association between eye and airway symptoms among allergy patients elicited by airborne chemicals, and contact dermatitis (positive patch test), but these symptoms were not related to positive skin prick test (immediate immune response) [Elberling et al. 2005]. Their findings suggest that individuals with contact allergy may have a predisposition to develop respiratory symptoms when exposed to airborne chemicals, which are common in airplane cabins.

A small minority of the reports we reviewed describe symptoms after working in close proximity or on the same aircraft with an employee who was wearing the uniform. We were not able to find scientific literature that addresses respiratory or dermal symptoms secondary to intermittent, close proximity to textiles worn by others.

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