

Occupational Contact Dermatitis in North American Mechanics and Repairers Referred for Patch Testing: Retrospective Analysis of Cross-Sectional Data From the North American Contact Dermatitis Group 1998 to 2014

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Background: Contact dermatoses are common in mechanic and repair occupations.

Objectives: This study aimed to (1) estimate the prevalence of occupationally related contact dermatitis among mechanics/repairers patch tested from 1998 to 2014 by the North American Contact Dermatitis Group, (2) characterize responsible allergens and irritants, and their sources, and (3) compare results among 3 occupational subgroups (mechanics, electrical/electronic, and other).

Methods: A cross-sectional analysis of patients patch tested by the North American Contact Dermatitis Group between 1998 and 2014.

Results: Of 38,784 patients patch tested, 691 (1.8%) were mechanics/repairers. Male sex (93.5%) and hand involvement (59.5%) were common overall. Occupationally related skin disease was more prevalent among vehicle and mobile equipment mechanics/repairers (52.7%) and other mechanics/repairers (41.4%) than electrical/electronic equipment mechanics/repairers (21.3%). Overall, carba mix, thiuram mix, and methylchloroisothiazolone/methylisothiazolone were the most common occupation-related clinically relevant allergens. Gloves, automotive vehicles, solvents, oils, lubricants, and fuels were the most common sources of responsible allergens.

Conclusions: Common occupationally related allergens included rubber accelerators and the preservative methylchloroisothiazolone/methylisothiazolone.

Occupational skin diseases and disorders (OSDs) are the number one cause of work-related illnesses in the US private sector workforce, accounting for 15.2% of all nonfatal occupational illnesses reported by the Bureau of Labor and Statistics in

2014.¹ In Canada, the incidence of OSD across all employment sectors is 4.6 cases per 10,000 full-time employees.² Contact dermatitis (CD) is the most common form of OSD in the United States and Canada.^{2,3}

Approximately 13 million US workers are exposed to occupationally related chemicals that can be absorbed through the

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skin.³ Equipment maintenance workers, mechanics, and repairers have contact with numerous chemicals and materials that are capable of causing irritant or allergic CD including oils, solvents, fuels, coatings, adhesives, skin cleansers, and rubber products.^{4,5}

Occupational CD frequently has a chronic course and is associated with morbidity, missed work, and significant disruptions in quality of life.^{6–8} In a recent study of hand dermatitis in Canadian mechanics, workers had experienced skin disease for 2 to 3 years before presentation and reported work absences due to OSD ranging from several days to 6 months.⁵

Although small studies investigating the prevalence of OSD have been published for specific subgroups of mechanics,^{4,5,9–11} there have not been comprehensive epidemiological studies of patch test reactions in North American mechanics. The purpose of this analysis was to establish the prevalence of occupationally related CD in North American Contact Dermatitis Group (NACDG)–member patch tested North American mechanics and repairers using 17 years of data from the NACDG. Furthermore, we identified responsible allergens, irritants, and sources.

METHODS

The NACDG Database

A total of 38,784 patients underwent patch testing by the NACDG between July 1, 1998 and December 31, 2014. All patients were patch tested to a screening series of 50 to 70 allergens. The NACDG methods of patch testing, reaction relevance, and final diagnoses were determined using established criteria.¹² Data collected by the NACDG include demographic information (age, sex, race, and occupation), site of dermatitis (up to 3 sites), final diagnoses (up to 3 diagnoses), and patch testing results including allergen name, strength of reaction, clinical relevance (definite, possible, probable, past), occupational relevance (yes or no), and exposure source.¹²

Between January 1998 and December 2000, exposure source was recorded using broad single-digit codes and therefore excluded from this analysis. From January 2001 to December 2014, sources were coded using more detailed 3-digit codes. Starting in January 2001, the occupational relevance and sources were recorded for all clinically relevant non-NACDG screening series allergens. Clinical history and known occupational exposures were used to determine occupational relevance.

The NACDG data were manually entered into a computerized database (Access; 2003, Microsoft Corporation, Redmond, WA). For this analysis, mechanics and repairers were defined using 3-digit 1990 US Census Industrial & Occupational Classification Codes.¹³ Occupational codes were determined by an occupational coding expert and based on a standardized questionnaire. Statistical analyses were performed using SAS 9.2 (Statistical Analysis System, SAS Institute Incorporated, Cary, NC).

Study Design

This retrospective analysis was approved by the Minneapolis Veterans Affairs Medical Center Human Studies Subcommittee.

Per the US Census Bureau's coding organization, mechanics were subdivided into 3 groups: vehicle and mobile equipment mechanics/repairers (occupational codes, 503–519), electrical and electronic equipment mechanics/repairers (occupational codes, 523–534), and other, miscellaneous mechanics and repairers (occupational codes, 535–549). We hypothesized that occupational exposures and potential relevant allergens and irritants may differ among subgroups of mechanics. Only positive allergic patch test reactions determined to be occupationally relevant were included in this analysis. Doubtful (macular erythema) reactions that were considered by the investigator to be irritant or not allergic in nature were excluded.

RESULTS

Overall Demographics

Between July 1, 1998 and December 31, 2014, a total of 38,784 patients were patch tested; 691 (1.8%) were mechanics and repairers as defined in Table 1. Table 2 summarizes patient

TABLE 1. Mechanic and Repairers Subgroups

Defined Subgroups (N = 691)	N
Group 1: Vehicle and Mobile Equipment Mechanics/Repairers	507
Automobile mechanics	203
Industrial machinery repairers	95
Bus, truck, and stationary engine mechanics	60
Automobile body and related repairers	37
Heavy equipment mechanics	37
Supervisors, mechanics, and repairers	28
Aircraft engine mechanics	25
Machinery maintenance occupations	8
Farm equipment mechanics	6
Aircraft mechanics, excluding engine	4
Small engine repairers	3
Automobile mechanic apprentices	1
Group 2: Electrical/Electronic Equipment Mechanics/Repairers	80
Heating, air conditioning, and refrigeration mechanics	19
Electronic repairers, communications, and industrial equipment	14
Miscellaneous electrical and electronic equipment repairers	14
Telephone installers and repairers	11
Telephone line installers and repairers	9
Data processing equipment repairers	7
Household appliance and power tool repairers	6
Group 3: Other Mechanics/Repairers	104
Millwrights	31
Not specified mechanics and repairers	31
Specified mechanics and repairers, nec	27
Locksmiths and safe repairers	6
Camera, watch, and musical instrument repairers	4
Mechanical controls and valve repairers	4
Office machine repairers	1

nec indicates not elsewhere classified.

TABLE 2. Demographics

Demographics	Total: All Mechanics & Repairers N = 691 (100.0%)	Group 1: Vehicle and Mobile Equipment Mechanics/Repairers N = 507 (73.4%)	Group 2: Electrical and Electronic Equipment Mechanics/Repairers N = 80 (11.6%)	Group 3: Other Mechanics/Repairers N = 104 (15.1%)
Men (n [%])	646 (93.5)	480 (94.7)	70 (87.5)	96 (92.3)
Age > 40 y (n [%])	435 (63.0)	321 (63.3)	40 (50.0)	74 (71.2)
White (n [%])	643 (93.1)	477 (94.1)	75 (93.8)	91 (87.5)
ORSD*	327 (47.2)	267 (52.7)	17 (21.3)	43 (41.4)
Atopy (n [%])				
Hay fever	173 (25.0)	122 (24.1)	24 (30.0)	27 (26.0)
Eczema	84 (12.2)	61 (12.0)	12 (15.0)	11 (10.6)
Asthma	62 (9.0)	42 (8.3)	9 (11.3)	11 (10.6)
Site (n [%])†				
Hand	411 (59.5)	320 (63.1)	35 (43.8)	56 (53.9)
Arm	236 (34.2)	192 (37.9)	24 (30.0)	20 (19.2)
Generalized	134 (19.4)	98 (19.3)	15 (18.8)	21 (20.2)
Face, scalp‡	100 (14.5)	60 (11.8)	19 (23.8)	21 (20.2)
Foot	85 (12.3)	52 (10.3)	14 (17.5)	19 (18.3)
Leg	81 (11.7)	58 (11.4)	11 (13.8)	12 (11.5)
Trunk	59 (8.5)	45 (8.9)	6 (7.5)	8 (7.7)
Neck	20 (2.9)	15 (3.0)	3 (3.8)	2 (1.9)
Most exposed areas	12 (1.7)	8 (1.6)	2 (2.5)	2 (1.9)
Anal/genital	8 (1.2)	5 (1.0)	1 (1.3)	2 (1.9)
Other	5 (0.7)	3 (0.6)	0 (0.0)	2 (1.9)
Only under clothing	4 (0.5)	4 (0.8)	0 (0.0)	1 (1.0)
Final diagnosis (n [%])§				
ACD	410 (59.3)	308 (60.8)	46 (57.5)	56 (53.9)
ICD	273 (39.5)	212 (41.8)	18 (22.5)	43 (41.4)
Other Dermatitis	87 (12.6)	61 (12.0)	15 (18.8)	11 (10.6)
Atopic Dermatitis	64 (9.3)	45 (8.8)	10 (12.5)	9 (8.7)
Psoriasis	50 (7.2)	36 (7.1)	9 (11.3)	5 (4.8)
Other Dermatoses	43 (6.2)	26 (5.1)	5 (6.3)	12 (11.5)
Nummular Eczema	18 (2.6)	16 (3.2)	1 (1.3)	1 (1.0)

*Refers to whether the patient had OSD in general, regardless of specific final diagnosis (eg, ICD, ACD).

†Total percentage may exceed 100% because up to 3 sites could be identified for each patient.

‡Including face, lips, nose, eyelids, eyes, ears, and scalp.

§Listed as 1 of 3 final diagnoses, therefore total percentage may exceed 100%. These numbers refer to prevalence of given final diagnosis in general, without regard to occupational relevance.

characteristics for the study population and each occupational subgroup. Overall, the majority were men (n = 646, 93.5%), older than 40 years (n = 435, 63.0%) or white (n = 643, 93.1%). Hands (n = 411, 59.5%), arms (n = 236, 34.2%), and generalized (n = 134, 19.4%) were the most common sites of involvement. Allergic contact dermatitis (ACD) was the most frequent final diagnosis (n = 410, 59.3%) followed by irritant contact dermatitis (ICD) (n = 273, 39.5%) and other dermatitis (n = 87, 12.6%).

Subgroup Demographics

Occupationally related skin disease (ORSD) (from any cause — ICD and/or ACD) was present in 47.2% of the overall study group. ORSD was significantly higher in vehicle and mobile equipment mechanics/repairers as compared with electrical mechanics/

repairers (risk ratio [RR], 2.48; 95% confidence interval [CI], 1.61–3.81) or other mechanics/repairers (RR, 1.27; 95% CI, 1.00–1.62). ORSD was also significantly higher in other mechanics/repairers as compared with electrical mechanics/repairers (RR, 1.95; 95% CI, 1.20–3.14).

ICD was significantly higher in vehicle and mobile equipment mechanics/repairers (RR, 1.86; 95% CI, 1.22–2.82) and other mechanics/repairers (RR, 1.84; 95% CI, 1.15–2.93) as compared with electrical mechanics/repairers, but there was no statistical difference between vehicle and mobile equipment mechanics/repairers and other mechanics/repairers (RR, 1.01; 95% CI, 0.79–1.30). There were no statistical differences in the 3 groups for overall rate of ACD (occupational or nonoccupational) (pairwise comparisons, data not shown).

TABLE 3. Prevalence of Occupationally Related NACDG Allergens

Allergen	All	Group 1	Group 2	Group 3
	Mechanics/Repairers	Vehicle and Mobile Equipment Mechanics/Repairers	Electronic/Electrical Equipment Mechanics/Repairers	Other Mechanics/Repairers
	N (%) N = 272	N (%) N = 229	N (%) N = 11	N (%) N = 32
Carba mix 3% pet	34 (12.5)	28 (12.2)	1 (9.1)	5 (15.6)
MCI/MI 100 ppm aq	30 (11.0)	27 (11.8)	0 (0.0)	3 (9.4)
Thiuram mix 1% pet	21 (7.7)	16 (7.0)	0 (0.0)	5 (15.6)
Potassium dichromate 0.25% pet	20 (7.4)	19 (8.3)	1 (9.1)	0 (0.0)
Formaldehyde 1% aq	15 (5.5)	13 (5.7)	1 (9.1)	1 (3.1)
Epoxy resin 1% pet	13 (4.8)	13 (5.7)	0 (0.0)	0 (0.0)
Nickel sulfate 2.5% pet	13 (4.8)	11 (4.8)	1 (9.1)	1 (3.1)
Methylisothiazolinone 0.2% aq (2000 ppm)	11 (4.0)	10 (4.4)	0 (0.0)	1 (3.1)
Mercaptobenzothiazole 1% pet	10 (3.7)	10 (4.4)	0 (0.0)	0 (0.0)
Cobalt chloride 1% pet	10 (3.7)	9 (3.9)	1 (9.1)	0 (0.0)
Glutaral 1% pet	7 (2.6)	6 (2.6)	1 (9.1)	0 (0.0)
Quaternium-15 2% pet	7 (2.6)	4 (1.7)	2 (18.2)	1 (3.1)
Colophony 20% pet	7 (2.6)	4 (1.7)	1 (9.1)	2 (6.3)
Fragrance mix 8% pet	6 (2.2)	4 (1.7)	0 (0.0)	2 (6.3)
Mixed dialkyl thioureas 1% pet	5 (1.8)	5 (2.2)	0 (0.0)	0 (0.0)
Propylene glycol 30% aq	5 (1.8)	4 (1.7)	0 (0.0)	1 (3.1)
Balsam of Peru 25% pet	5 (1.8)	3 (1.3)	0 (0.0)	2 (6.3)
Black rubber mix 0.6% pet	4 (1.5)	4 (1.7)	0 (0.0)	0 (0.0)
Bacitracin 20% pet	4 (1.5)	3 (1.3)	0 (0.0)	1 (3.1)
Mercapto mix 1% pet	3 (1.1)	3 (1.3)	0 (0.0)	0 (0.0)
Iodopropynyl butyl carbamate 0.5% pet	3 (1.1)	3 (1.3)	0 (0.0)	0 (0.0)
Methyldibromo glutaronitrile/ phenoxyethanol 2.0% pet	3 (1.1)	3 (1.3)	0 (0.0)	0 (0.0)
Lanolin alcohol 30%–50% pet	3 (1.1)	3 (1.3)	0 (0.0)	0 (0.0)
Neomycin sulfate 20% pet	3 (1.1)	2 (0.9)	0 (0.0)	1 (3.1)
Propylene glycol 100%	3 (1.1)	1 (0.4)	1 (9.1)	1 (3.1)
p-tert-butylphenol formaldehyde resin 1% pet	2 (0.7)	2 (0.9)	0 (0.0)	0 (0.0)
Sesquiterpene lactone mix 0.1% pet	2 (0.7)	2 (0.9)	0 (0.0)	0 (0.0)
Diazolidinyl urea 1% aq	2 (0.7)	2 (0.9)	0 (0.0)	0 (0.0)
Amidoamine 0.1% aq	2 (0.7)	2 (0.9)	0 (0.0)	0 (0.0)
2-Bromo-2-nitropropane-1,3-diol 0.5% pet	2 (0.7)	2 (0.9)	0 (0.0)	0 (0.0)
Methyl methacrylate 2% pet	2 (0.7)	1 (0.4)	0 (0.0)	1 (3.1)
Cocamide diethanolamine 0.5% pet	1 (0.4)	1 (0.4)	0 (0.0)	0 (0.0)
Diazolidinyl urea 1% pet	1 (0.4)	1 (0.4)	0 (0.0)	0 (0.0)
Benzocaine 5% pet	1 (0.4)	1 (0.4)	0 (0.0)	0 (0.0)
P-phenylenediamine 1% pet	1 (0.4)	1 (0.4)	0 (0.0)	0 (0.0)
DMDM hydantoin 1% pet	1 (0.4)	1 (0.4)	0 (0.0)	0 (0.0)
Formaldehyde, 2.0% aq.	1 (0.4)	1 (0.4)	0 (0.0)	0 (0.0)
Compositae mix 6% pet	1 (0.4)	1 (0.4)	0 (0.0)	0 (0.0)
Dithiomorpholine 1% pet	1 (0.4)	1 (0.4)	0 (0.0)	0 (0.0)
DMDM hydantoin 1% aq	1 (0.4)	1 (0.4)	0 (0.0)	0 (0.0)
Thimerosal 0.1% pet	1 (0.4)	1 (0.4)	0 (0.0)	0 (0.0)
Ethyleneurea melamine formaldehyde 5% pet	1 (0.4)	0 (0.0)	1 (9.1)	0 (0.0)
Ethyl acrylate 0.1% pet	1 (0.4)	0 (0.0)	0 (0.0)	1 (3.1)
2-Hydroxyethyl methacrylate, 2.0% pet	1 (0.4)	0 (0.0)	0 (0.0)	1 (3.1)
Diphenylguanidine 1.0%	1 (0.4)	0 (0.0)	0 (0.0)	1 (3.1)
Fragrance mix II, 14.0% pet	1 (0.4)	0 (0.0)	0 (0.0)	1 (3.1)

DMDM indicates dimethyldimethylhydantoin.

Occupationally Related NACDG Allergen Frequencies by Subgroups

The prevalence of all occupationally related NACDG reactions for the total study population and each subgroup are outlined in Table 3. Frequencies of the top 10 occupationally related NACDG allergens with specific allergen sources are detailed by occupational subgroup in Tables 4–6. Carba mix, methylchloroisothiazolone/methylisothiazolone (MCI/MI), and potassium dichromate were the most common occupationally related allergens in vehicle and mobile equipment mechanics/repairers. Quaternium-15, carba mix, and formaldehyde were the most frequent occupationally related allergens in electrical mechanics/repairers. For other mechanics/repairers, carba mix, thiuram mix, and MCI/MI were the top allergens.

The NACDG Allergen Sources

Sources of occupationally related NACDG screening series allergens for mechanics patch tested between 1998 and 2014 are

summarized in Table 7. Gloves (n = 34), automotive vehicles (n = 32), and waterless hand sanitizers (n = 18) were the most frequent sources of allergens in vehicle and mobile equipment mechanics/repairers. Metalworking fluids and cutting oils (n = 2), clothing (n = 2), and personal care products (n = 2) were the most common allergen sources for electronics and electrical equipment mechanics/repairers. Gloves (n = 7); nonskin soaps (n = 4); and adhesives, glues, and bonding agents (n = 3) were the top allergen sources in other mechanics/repairers.

Non-NACDG Allergens

There were 99 non-NACDG allergen sources identified in the overall study group (Table 8). Chemical products were the most common sources of occupationally related non-NACDG allergens. Adhesives, glues, and bonding agents (n = 11); lubricating oils and greases (n = 9); and automotive oils and fluids (n = 7) were the top sources of other allergens in vehicle and mobile equipment mechanics/repairers. In electrical/electronic equipment mechanics/repairers,

TABLE 4. Group 1 — Vehicle and Mobile Equipment Mechanics/Repairers: Occupationally Related NACDG Screening Allergens and Top 5 Sources

Allergen	Source (No. Patients)	Source (No. Patients)	Source (No. Patients)	Source (No. Patients)	Source (No. Patients)	Total*
Carba mix 3% pet	Gloves (13)	Automotive vehicles (7)	Machinery and vehicles, nos (2)	Material handling machinery (1)	Special applications and processing machinery (1)	28
MCI/MI 100 ppm aq	Waterless hand soaps (10)	Nonskin soaps and detergents (4)	Liquid/lotion/bar skin soaps and cleaners (3)	Metalworking fluid, cutting oils (3)	Skin soaps and cleansers, nos (2)	27
Potassium dichromate 0.25% pet	Automotive vehicles (5)	Gloves (4)	Metallic elements, dusts, powders, fumes (2)	Coatings (2)	Automotive oils and fluids (2)	19
Thiuram mix 1% pet	Gloves (10)	Automotive vehicles (4)	Safety equipment, miscellaneous (1)	Lubricating oils and greases (1)	—	16
Bisphenol A 1% pet	Coatings (4)	Adhesives (4)	Epoxy resins (2)	Gloves (1)	Automotive oils and fluids (1)	13
Formaldehyde 1% aq	Automotive oils and fluids (2)	Liquid/lotion/bar skin soaps and cleaners (2)	Coatings & adhesives (2)	Lubricating oils and greases (1)	Metalworking fluid, cutting oils (1)	13
Nickel sulfate 2.5% pet	Automotive vehicles (4)	Metallic elements, dusts, powders, fumes (3)	Lubricating oils and greases (1)	Building & construction materials, tools, equipment, supplies (1)	Jewelry (1)	11
Mercaptobenzothiazole 1% pet	Gloves (6)	Vehicles (2)	Lubricating oils and greases (1)	—	—	10
Methylisothiazolinone 0.2% aq (2000 ppm)†	Waterless hand soaps (3)	Liquid/lotion/bar skin soaps and cleaners (2)	Skin soaps and cleansers, nos (1)	Moisturizers, lotions, creams (1)	Nonskin soaps and detergents (1)	10
Cobalt chloride 1% pet	Metallic elements, dusts, powders, fumes (2)	Automotive vehicles (2)	Tools (2)	Lubricating oils and greases (1)	Automotive oils and fluids (1)	9

*Total includes additional sources.

†Only tested for 1 cycle.

nos indicates not otherwise specified.

TABLE 5. Group 2 — Electrical and Electronic Equipment Mechanics/Repairers: Occupationally Related NACDG Screening Allergens and Top Source

Allergen	Source (No. Patients)	Total
Quaternium-15 2% pet	Moisturizers, lotions, creams (1)	2*
Carba mix 3% pet	Gloves (1)	1
Formaldehyde 1% aq	Metalworking fluid, cutting oils (1)	1
Cobalt chloride 1% pet	Lubricating oils and greases (1)	1
Nickel sulfate 2.5% pet	Metallic elements, dusts, powders, fumes (1)	1
Potassium dichromate 0.25% pet	Cement, concrete, mortar (1)	1
Colophony 20% pet	Building systems (heating/cooling/plumbing/ventilation) (1)	1
Glutaral 1% pet	Waterless hand soaps (1)	1
Ethyleneurea melamine formaldehyde 5% pet	Shirts, pants, blouses, dresses, skirts (1)	1
Propylene glycol 100%	Metalworking fluid, cutting oils (1)	1

*Includes 1 unknown source.

lubricating oils and greases (n = 1), metalworking fluids and cutting oils (n = 1), and amines (n = 1) were common sources of non-NACDG allergens. Lubricating oils and greases (n = 2), formaldehyde resins (n = 1), and agricultural chemicals (n = 1) were the top sources of other allergens in other mechanics/repairers.

Relevant Occupational Irritants

Occupationally related irritants were most commonly attributed to chemicals and chemical products in all 3 mechanic groups (Table 9). The most common sources of relevant occupational irritants in vehicle and mobile equipment mechanics/repairers were automotive oils and fluids (n = 54); solvents, oils, lubricants, and fuels (n = 33); and lubricating oils and greases (n = 26). Lubricating oils and greases (n = 2) were the most common sources of irritants in electrical/electronic mechanics/repairers followed by

petroleum-related products (n = 2) and metalworking fluids and cutting oils (n = 1). Solvents, oils, lubricants, and fuels (n = 7); metalworking fluids, cutting oils (n = 2); and solvents, degreasers, and petroleum distillates (n = 2) were frequently observed irritant sources in other mechanics/repairers.

DISCUSSION

This large-scale retrospective analysis of North American mechanics and repairers patch tested by the NACDG through a 17-year period documents several key findings. First, ORSD was common among all mechanic subgroups and was twice as likely in vehicle and mobile equipment mechanics/repairers as in electrical/electronic equipment repairers. Second, hand and arm involvement were the most frequent sites of dermatitis. Third, rubber accelerators, preservatives, metals, and adhesives were frequent occupationally related allergens. Automotive vehicles, gloves, waterless hand sanitizers, and solvents/oils/lubricant/fuels were common sources of these allergens. Oils/solvents/lubricants/fuels were also the most identified sources of occupational irritants.

Sex, Final Diagnosis, Site of Dermatitis, and Occupational Relatedness

Overall, mechanics displayed a high rate of ORSD (47.2%). Of the subgroups, electrical/electronic equipment mechanics/repairers had lower rates of OSD (21.3%) compared with vehicle and mobile equipment mechanics/repairers (52.7%) and other mechanics/repairers (41.35%). Mechanics are likely prone to occupational CD because of friction and vibration against the skin from tools and machinery and exposure to a variety of irritants and allergens as well as frequent hand cleansing with soaps and industrial detergents and solvents that may further damage the skin's barrier function.

Men (93.5%) were predominant in all groups reflecting their high prevalence in mechanic and repair occupations. In 2015, the

TABLE 6. Group 3 — Other Mechanics/Repairers: Occupationally Related NACDG Standard Allergens and Top 3 Sources

Allergen	Source (No. Patients)	Source (No. Patients)	Source (No. Patients)	Total
Carba mix 3% pet	Gloves (4)	Recreational/athletic equipment (1)	—	5
Thiuram mix 1% pet	Gloves (3)	Recreational/athletic equipment (1)	Safety equipment (1)	5
MCI/MI 100 ppm aq	Shampoo (1)	Liquid/lotion/bar skin soaps and cleansers (1)	Pumice soap (1)	3
Colophony 20% pet	Trees and logs (1)	Shoes, boots, sandals, slippers (1)	—	2
Balsam of Peru 25% pet	Nonskin soaps and detergents (2)	—	—	2
Fragrance mix 8% pet	Nonskin soaps and detergents (2)	—	—	2
Formaldehyde 1% aq	Fiberglass insulation (1)	—	—	1
Nickel sulfate 2.5% pet	Fiberglass insulation (1)	—	—	1
Ethyl acrylate 0.1% pet	Adhesives (1)	—	—	1
2-Hydroxyethyl methacrylate, 2.0% pet	Adhesives (1)	—	—	1

TABLE 7. Sources of Occupationally Related NACDG Allergens in Mechanics and Repairers

Category	Group 1 Vehicle and Mobile Equipment Mechanics/ Repairers N (%) N = 229	Group 2 Electrical/ Electronic Mechanics/ Repairers N (%) N = 11	Group 3 Other Mechanics/ Repairers N (%) N = 32
Chemicals & chemical products	64 (28.0)	4 (36.4)	5 (15.6)
Automotive oils and fluids	11 (4.8)	0 (0.0)	0 (0.0)
Solvents, oils, lubricants, fuels	10 (4.4)	0 (0.0)	0 (0.0)
Coatings	9 (3.9)	0 (0.0)	0 (0.0)
Adhesives, glues, bonding agents	7 (3.1)	0 (0.0)	3 (9.4)
Metallic elements, dusts, powders, fumes	7 (3.1)	1 (9.1)	0 (0.0)
Lubricating oils/greases	7 (3.1)	1 (9.1)	0 (0.0)
Metalworking fluids, cutting oils	6 (2.6)	0 (0.0)	0 (0.0)
Epoxy resins	2 (0.9)	0 (0.0)	1 (3.1)
Solvents, degreasers, petroleum distillates	2 (0.9)	0 (0.0)	0 (0.0)
Metalworking fluids, cutting oils	0 (0.0)	2 (18.2)	1 (3.1)
Miscellaneous chemical mixtures	1 (0.4)	0 (0.0)	0 (0.0)
Aldehydes	1 (0.4)	0 (0.0)	0 (0.0)
Coatings, adhesives, dyes, inks, photographic and copying chemicals (general)	1 (0.4)	0 (0.0)	0 (0.0)
Personal care products	45 (19.7)	2 (18.2)	7 (21.9)
Waterless hand soaps	18 (7.9)	1 (9.1)	0 (0.0)
Liquid, lotion, and bar soaps and cleaners	12 (5.2)	0 (0.0)	2 (6.3)
Soaps and cleansers (personal hygiene)	6 (2.6)	0 (0.0)	0 (0.0)
Moisturizers, lotions, creams	4 (1.8)	1 (9.1)	1 (3.1)
Other personal care products	3 (1.3)	0 (0.0)	2 (6.3)
Shampoos	2 (0.9)	0 (0.0)	2 (6.3)
Pumice soaps			
Clothing	41 (17.9)	2 (18.2)	9 (28.1)
Gloves	34 (14.9)	1 (9.1)	7 (21.9)
Safety equipment	3 (1.3)	0 (0.0)	1 (3.1)
Shoes, boots	3 (1.3)	0 (0.0)	1 (3.1)
Other clothing	1 (0.4)	1 (9.1)	0 (0.0)
Machinery/vehicles	38 (16.6)	0 (0.0)	0 (0.0)
Automotive vehicles (air, rail, road, water)	32 (14.0)	0 (0.0)	0 (0.0)
Machinery and automotive vehicles	2 (0.9)	0 (0.0)	0 (0.0)
Heating, cooling, cooking, and cleaning machinery and appliances	2 (0.9)	0 (0.0)	0 (0.0)
Material handling machinery	1 (0.4)	0 (0.0)	0 (0.0)
Special applications and processing machinery	1 (0.4)	0 (0.0)	0 (0.0)
Building & construction materials, tools, equipment, supplies	7 (3.1)	1 (9.1)	5 (15.6)
Tools	3 (1.3)	0 (0.0)	0 (0.0)
Building materials	1 (0.4)	0 (0.0)	0 (0.0)
Cement, concrete, mortar	1 (0.4)	0 (0.0)	0 (0.0)
Wood, lumber	1 (0.4)	0 (0.0)	0 (0.0)
Sealants, caulking & insulating materials	1 (0.4)	0 (0.0)	0 (0.0)
Fiberglass insulation	0 (0.0)	0 (0.0)	2 (6.3)
Recreation and athletic equipment	0 (0.0)	0 (0.0)	3 (9.4)
Soaps and detergents (nonskin)	7 (3.1)	0 (0.0)	4 (12.5)
Medications	6 (2.6)	0 (0.0)	2 (6.3)
Biologic materials	3 (1.3)	0 (0.0)	0 (0.0)
Furniture, fixtures, structures, and surfaces	0 (0.0)	1 (9.1)	0 (0.0)
Other (unknown + NA)	18 (7.9)	1 (9.1)	0 (0.0)

TABLE 8. Sources of Non-NACDG Occupationally Related Allergens

Source	Group 1	Group 2	Group 3
	Vehicle and Mobile Equipment Mechanics/ Repairers N (%) N = 79	Electrical/Electronic Equipment Mechanics/ Repairers N (%) N = 6	Other Mechanics/ Repairers N (%) N = 14
Chemicals & chemical products	41 (51.9)	3 (50.0)	6 (42.9)
Adhesives, glues, bonding agents	11 (13.9)	0 (0.0)	1 (7.1)
Lubricating oils & greases	9 (11.4)	1 (16.7)	2 (14.3)
Automotive oils and fluids	7 (8.9)	0 (0.0)	0 (0.0)
Solvents, oils, lubricants, fuels	4 (5.1)	0 (0.0)	0 (0.0)
Coatings (paint, lacquer, shellac, varnish, stains)	3 (3.8)	0 (0.0)	0 (0.0)
Metalworking fluids, cutting oils	2 (2.5)	1 (16.7)	0 (0.0)
Urethane resins	1 (1.3)	0 (0.0)	0 (0.0)
Amines	1 (1.3)	1 (16.7)	0 (0.0)
Epoxy resins	1 (1.3)	0 (0.0)	0 (0.0)
Metallic elements, dusts, powders, fumes	1 (1.3)	0 (0.0)	0 (0.0)
Pesticides, horticultural and agricultural chemicals	0 (0.0)	0 (0.0)	1 (7.1)
Photographic chemicals	0 (0.0)	0 (0.0)	1 (7.1)
Formaldehyde resins	0 (0.0)	0 (0.0)	1 (7.1)
Miscellaneous chemical mixtures	1 (1.3)	0 (0.0)	0 (0.0)
Personal care products	9 (11.4)	2 (33.3)	1 (7.1)
Waterless hand soaps	3 (3.8)	0 (0.0)	0 (0.0)
Liquid, lotion, and bar soaps, and cleaners	2 (2.5)	1 (16.7)	0 (0.0)
Moisturizers, lotions, creams	1 (1.3)	1 (16.7)	0 (0.0)
Personal care products, nos	1 (1.3)	0 (0.0)	0 (0.0)
Pumice soaps	1 (1.3)	0 (0.0)	0 (0.0)
Tapes, Band Aids, adhesive aids	1 (1.3)	0 (0.0)	0 (0.0)
Machinery/vehicles	6 (7.6)	0 (0.0)	1 (7.1)
Vehicles (air, rail, road, water)	3 (3.8)	0 (0.0)	0 (0.0)
Material handling machinery	2 (2.5)	0 (0.0)	0 (0.0)
Heating, cooling, cooking, and cleaning machinery and appliances	1 (1.3)	0 (0.0)	0 (0.0)
Clothing, textiles	6 (7.6)	0 (0.0)	2 (14.3)
Soaps, detergents (nonskin)	6 (7.6)	0 (0.0)	0 (0.0)
Plants & minerals	3 (3.8)	0 (0.0)	2 (14.3)
Building & construction materials, tools, equipment, supplies	2 (2.5)	0 (0.0)	1 (7.1)
Medications	1 (1.3)	1 (16.7)	0 (0.0)
Other	5 (6.3)	0 (0.0)	1 (7.1)

US Bureau of Labor and Statistics Current Population Statistics reported that women comprise only 3.5% of all installation, maintenance, and repair workers.¹⁴ Allergic contact dermatitis (59.3%), followed by ICD (39.5%), and *other dermatitis* (12.6%) were the most common final diagnoses across all 3 mechanic subgroups. This finding is expected and consistent with previously published studies demonstrating high rates of CD in mechanics. However, some previous studies have shown higher rates of ICD compared with ACD in mechanics and maintenance workers.^{4,10,15} The higher rate of ACD in our study cohort is likely due to referral bias; only mechanics thought to likely have ACD would have been referred for patch testing.

Notably, dermatitis in mechanics primarily affected the hands (59.5%) and arms (34.2%). Previous studies demonstrated between 15%

and 45% occurrence of hand dermatitis in mechanics within the past year.^{9,11} This finding is not surprising because gloves were a common source of occupationally related allergens. Mechanics are also exposed to numerous hand cleansers and sanitizers because of the need for frequent hand washing after contact with chemicals and dirt.

Allergens and Their Sources: Mechanics and Repairers Overall

The top 3 currently relevant and occupationally related allergens in mechanics overall were carba mix, thiuram mix, and MCI/MI. These common allergens are consistent with known workplace exposures for mechanics including gloves, automotive vehicles, machinery, soaps, and hand sanitizers, respectively.

TABLE 9. Sources of Non-NACDG Occupationally Related Irritants

Category	Group 1 Vehicle and Mobile Equipment Mechanics/ Repairers N (%)	Group 2 Electronic/Electrical Equipment Mechanics/ Repairers N (%)	Group 3 Other Mechanics/ Repairers N (%)
	N = 182	N = 13	N = 26
Chemicals & chemical products	152 (83.5)	5 (38.5)	17 (65.4)
Automotive oils and fluids	54 (29.7)	0 (0.0)	0 (0.0)
Solvents, oils, lubricants, fuels, nos	33 (18.1)	0 (0.0)	7 (26.9)
Lubricating oils & greases	26 (14.3)	2 (15.4)	0 (0.0)
Solvents, degreasers, petroleum distillates	20 (11.0)	1 (7.7)	2 (7.7)
Metalworking fluids, cutting oils	5 (2.8)	1 (7.7)	2 (7.7)
Gasoline, diesel, jet fuel	5 (2.8)	0 (0.0)	1 (3.9)
Adhesives, glues, bonding agents	2 (1.1)	0 (0.0)	0 (0.0)
Petroleum (crude) and products	0 (0.0)	1 (7.7)	1 (3.9)
Coatings, adhesives, dyes, inks, photographic and copying chemicals, nos	1 (0.6)	0 (0.0)	0 (0.0)
Coatings (paint, lacquer, shellac, varnish, stains)	1 (0.6)	0 (0.0)	0 (0.0)
Metallic elements, dusts, powders, fumes	0 (0.0)	0 (0.0)	2 (7.7)
Automotive oils and fluids	0 (0.0)	0 (0.0)	1 (3.9)
Coal & coal products	1 (0.6)	0 (0.0)	0 (0.0)
Alkalies	1 (0.6)	0 (0.0)	0 (0.0)
Ketones	0 (0.0)	0 (0.0)	1 (3.9)
Epoxy resins	1 (0.6)	0 (0.0)	0 (0.0)
Phenolic resins	1 (0.6)	0 (0.0)	0 (0.0)
Miscellaneous chemical mixtures	1 (0.6)	0 (0.0)	0 (0.0)
Soaps, detergents (nonskin)	7 (3.9)	1 (7.7)	1 (3.9)
Personal care products	5 (2.8)	0 (0.0)	0 (0.0)
Machinery/vehicles	3 (1.7)	0 (0.0)	0 (0.0)
Clothing, textiles	1 (0.6)	2 (15.4)	1 (3.9)
Plants & minerals	1 (0.6)	0 (0.0)	2 (7.7)
Building & construction materials, tools, equipment, supplies	1 (0.6)	2 (15.4)	5 (19.2)
Other	12 (6.6)	3 (23.1)	0 (0.0)

Rubber chemicals were the most common allergens overall, and gloves, machinery, and vehicles were the most common sources for these allergens. Rubber chemicals are a well-known cause of occupationally related ACD.^{16–20} The protective gloves used by many mechanics contain additives from the rubber manufacturing process such as carbamates, thiurams, and mercaptobenzothiazoles. Antioxidants and dyes are also added to many gloves and are frequently responsible for sensitization. Automotive vehicles and machinery in general were also frequent sources of rubber allergens. Possible specific sources of rubber include rubber gaskets, seals, tubing, and tires.

The preservatives MCI/MI and MI alone were common allergens in mechanics and repairers overall. MCI/MI or MI are found in more than 1000 personal care products, including many cleansers, hand soaps, and other skin care products.²¹ Although waterless hand sanitizers used in health care are uncommon sources of allergens, waterless hand cleansers marketed to mechanics were a frequent source of ACD caused by MCI/MI. We suspect that this will likely increase as MCI/MI and MI alone are increasingly used in cleansers.²² Furthermore, this analysis includes only testing to MI

alone for a 2-year cycle (2013–2014). This finding is highly relevant for mechanics because this occupational group requires frequent hand cleaning because of the dirty nature of their work.

A recent Danish study by Schwensen et al²³ analyzed selected allergens from the European baseline series in blue-collar workers. In mechanics (not otherwise specified), reaction rates were 4.5% (7/156) to MCI/MI, 3.8% (6/156) to epoxy resin, 3.8% (6/156) to methyldibromo glutaronitrile, and 1.9% (3/156) to potassium dichromate.²³ In our overall study population of mechanics/repairers, we found more frequent positive reactions to MCI/MI (n = 30/272; 11.0%), epoxy resin (n = 13/272; 4.8%), and potassium dichromate (n = 20/272; 7.4%). We noted a similar prevalence of occupational ACD to methyldibromo glutaronitrile (n = 3/272; 1.1%).

Occupational Subgroups

Vehicle and mobile equipment mechanics/repairers diagnose, adjust, repair, and overhaul automobiles; aircraft; farm equipment; heavy equipment; and small engines from motorboats, motorcycles,

and outdoor power equipment. This subgroup also includes tire repairers and changers as well as automotive glass and body repairers. Electrical mechanics/repairers repair, install, and maintain a variety of electronic equipment including home entertainment and radio equipment; electronic communications systems (sound, sonar, security, navigation, and surveillance systems); and industrial controls, transmitters, and antennas. Other mechanics/repairers include millwrights who install, dismantle, or move machinery or heavy equipment according to layout plans. This subgroup also includes locksmiths who repair and open locks, make keys, and repair safes as well as workers who repair and adjust precision equipment (cameras, medical equipment, watches, musical instruments).

We expected the vehicle and mobile equipment mechanic/repairer subgroup to demonstrate high frequencies of occupationally related ACD to rubber chemicals, metals, and preservatives given known occupational exposures to oils, solvents, cleansers, metal, and rubber tools/parts. In Canada, Donovan et al⁵ performed a chart review of 32 patch tested auto mechanics. The most common allergens reported in that analysis were 1,2-dibromo-2,4-dicyanobutane + phenoxyethanol (Euxyl K400; Shulke & Myr GmbH Company, Norderstedt, Germany) ($n = 5/32$; 15.6%), 5-chloro-2-methyl-4-isothiazolin-3-one and 2-methyl-4-iso-thiazolin-3-one (Kathon CG; Rohm and Haas, Philadelphia, PA) ($n = 4/32$; 12.5%), carba mix ($n = 3/32$; 9.4%), and potassium dichromate ($n = 3/32$; 9.4%).⁵ Carba mix and potassium dichromate were also in the top 4 most frequent occupationally related allergens in vehicle mechanics/repairers in our analysis.

Not surprisingly, metals and preservatives were common allergens in electrical and electronic equipment mechanics/repairers. Occupational sources of these allergens included moisturizers, metal-working fluids and cutting oils, metallic elements, and waterless hand soaps. Other mechanics and repairers demonstrated similar allergens to the vehicle and mobile equipment mechanics/repairers including rubber chemicals (thiuram mix, carba mix) and MCI/MI. This group also demonstrated occupationally related ACD to a number of chemicals commonly found in adhesives including ethyl acrylate, 2-hydroxyethyl methacrylate, methyl methacrylate, and colophony. These findings are not unexpected given occupational exposure to gloves, adhesives, and cleansers.

There were no statistical differences among the 3 subgroups for overall rate of ACD (occupational or nonoccupational). However, ICD was significantly more common in vehicle and mobile equipment mechanics/repairers and other mechanics/repairs as compared with electrical mechanics/repairers.

Limitations

There are several limitations to this study. First, as a cross-sectional analysis, it cannot determine causal relationships. A large prospective study is necessary to fully elucidate the development of ACD in mechanics. Second, the designation of source was limited by the practitioner's knowledge of occupational contacts and existing set of codes. For example, *automotive vehicles* were a frequent

source of occupationally related allergens, but the source coding system used for this analysis does not further define vehicle parts (eg, tires, rubber tubing). Third, this cohort represents a referral population and therefore may not be generalizable to other groups. Furthermore, we did not subdivide by geographic location. Fourth, length of occupation and duration and course of dermatitis are not collected by the NACDG. Finally, additional allergen series and specific names of non-NACDG allergens and irritants are not recorded.

CONCLUSIONS

Among patients patch tested by members of the NACDG between 1998 and 2014, male sex, ORSD, and hand and arm dermatitis were common in mechanics and repairers. Rubber accelerators (carba mix, thiuram mix, mercaptobenzothiazole), metals (potassium dichromate, nickel, cobalt), and preservatives (MCI/MI, formaldehyde, quaternium-15) were the most frequently identified occupationally relevant allergens. Gloves, automotive vehicles, and waterless hand soaps were the most common occupationally related sources of NACDG allergens in mechanics. The top irritant sources included solvents, oils, lubricants, and fuels.

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