

ORIGINAL ARTICLE

A review of non-glove personal protective equipment-related occupational dermatoses reported to EPIDERM between 1993 and 2013

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Background: Personal protective equipment (PPE) is defined as equipment that protects the wearer's body against health/safety risks at work. Gloves cause many dermatoses. Non-glove PPE constitutes a wide array of garments. Dermatoses resulting from these have hitherto not been documented.

Objectives: To determine the incidence and types of non-glove PPE-related dermatoses.

Patients/Methods: We analysed incident case reports from dermatologists of non-glove PPE-related dermatoses to a UK-wide surveillance scheme (EPIDERM) between 1993 and 2013.

Results: The dermatoses associated with non-glove PPE accounted for 0.84% of all occupational skin disease. Of all PPE-related cases, 194 (9.2%) were attributable to non-glove PPE. Of these, 132 (68.0%) occurred in men, and the median age (both male and female) was 42 years (range 18–82 years). The non-glove PPE-related dermatoses were diagnosed as: allergic contact dermatitis (47.4%), irritant contact dermatitis (16.0%), friction (11.3%), occlusion (11.3%), unspecified dermatitis (8.8%), acne (3.1%), infections (1.5%), and contact urticaria (0.52%). The industries most associated with non-glove PPE-related dermatoses were manufacturing (18.6%), public administration and defence (17.0%), health and social work (15.5%), and transport, storage, and communication (9.8%).

Conclusions: Clothing, footwear, facemasks and headgear need to be recognized as causes of dermatoses occurring at body sites less commonly associated with occupational skin disease.

KEYWORDS

acne, allergen, allergic contact dermatitis, friction, infection, irritant contact dermatitis, occlusion, personal protective equipment

1 | INTRODUCTION

In 2016–17, the UK Labour Force Survey (LFS) estimated that 1.3 million people suffered with work-related ill health.¹ There were an estimated 6000 new cases of self-reported skin problems annually that were caused or exacerbated by work. In 2016, an estimated 1207 individuals with new cases of occupational skin disease were reported by dermatologists to EPIDERM, an occupational skin surveillance scheme that is part of The Health and Occupation Research (THOR) network. There were 1261 new diagnoses among these individuals,

and, of these, 932 (74%) were contact dermatitis. Analyses of EPIDERM data for 1996 to 2016 showed that approximately 37% of cases of contact dermatitis were allergic in nature, 44% were irritant, and the remainder were mixed or unspecified.²

In 2012–14, personal protective equipment (PPE) was the fourth most commonly reported cause of occupational contact dermatitis reported to EPIDERM, accounting for 127 of all cases (7.0%).² PPE is defined as equipment that is worn, and protects the wearer's body against health or safety risks at work, for example, clothing and/or eye protection. It includes items such as safety helmets, gloves, high-visibility

clothing, safety footwear, safety harnesses, and respiratory protective equipment. PPE should be used as a last resort whenever there are risks to health and safety that cannot be adequately controlled in other ways. In the United Kingdom, the Personal Protective Equipment at Work Regulations 1992 require PPE to be supplied by employers.³

Despite the wide range of types of PPE, most of the literature in relation to PPE-associated dermatoses is focused on gloves.^{4,5} The aim of this study was to determine the incidence and types of dermatoses associated with non-glove PPE.

2 | METHODS

This study analysed incident case reports of non-glove PPE-related dermatoses submitted to EPIDERM by dermatologists between 1993 and 2013. EPIDERM reporters are asked to submit new cases of occupational skin disease seen in their clinical practice during their allocated reporting period (which can be every month ["core" reporters] or for one randomly chosen month per year ["sample" reporters]).

Collated variables included diagnosis, employment, suspected agents, and demographic data. The categories under "diagnosis" included allergic contact dermatitis (ACD), irritant contact dermatitis (ICD), friction, occlusion, acne, infections, contact urticaria, and unspecified dermatitis. The time period chosen for this study included the pilot period for EPIDERM (1993 to 1995 inclusive). On average, 190 dermatologists per year reported to EPIDERM over the time period 1993 to 2013.

Descriptive statistics based on the actual number of cases reported, as well as the estimated number of cases, by type of PPE, industry and occupation are provided. Annual average incidence rates (per 100 000 persons employed per year) by industry and occupation were calculated for the period 1996 to 2013 (information on industry was not routinely collected during the pilot period). The numerator was the estimated case counts, adjusted to take into account the proportion of UK physicians participating in EPIDERM and the proportion of physicians responding during their reporting month(s).⁶ The denominator was the number of persons employed (1996-2013) according to the LFS.

North West-Haydock Research Ethics Committee approval has been granted to THOR (Reference number REC 17/NW/0129).

3 | RESULTS

Twenty-three thousand one hundred and eighty-six actual cases of work-related dermatosis were reported to EPIDERM over the 20-year

period analysed. Of these, 2107 (9.1%) were related to PPE. Glove-related dermatoses accounted for 1913 cases (90.8%) of PPE-related dermatoses. Non-glove cases accounted for 194 (9.2%) PPE-related dermatoses. Of these, 132 (68.0%) occurred in men and 62 (32.1%) in women. The median age was 42 years (range 18-82 years; SD 12.1 years). Table 1 shows the types of non-glove PPE associated with dermatoses/causes of dermatoses.

Forty-nine cases of ACD were caused by personal protective footwear. Exposures associated with PPE footwear-related ACD included rubber (22 cases), leather (17 cases), metal (two cases) and adhesives in boots (one case). Seven of the associated exposures were not documented. The allergens associated with footwear were reported in 35 cases. Those that were documented were: potassium dichromate (10 cases), *p*-phenylenediamine (PPD) (five cases), nickel (five cases), carba mix (three cases), thiuram mix (two cases), mercapto mix (two cases), colophonium (two cases), cobalt (one case), *N*-isopropyl-*N*-phenyl-*p*-phenylenediamine (IPPD) (one case), Disperse Blue 35, 85 and 106 (one case), Disperse Blue (exact dye unspecified) (one case), Reactive Red 238 (one case), and azo dyes (exact dye unspecified) (one case).

Thirty-four cases of ACD were associated with clothing. Exposures associated with PPE clothing-related ACD included dyes (20 cases), rubber (seven cases), metal (two cases), leather (two cases), fabric finish (two cases), and adhesives in a disposable gown (one case). Eighteen clothing-related allergens were reported: thiurams (three cases), diethylthiourea (two cases), nickel (two cases), Disperse Blue (unspecified) (two cases), formaldehyde (two cases), azo dyes (unspecified) (one case), potassium dichromate (one case), Disperse Blue 106/124 (one case), Disperse Orange (unspecified) (one case), Disperse Yellow (unspecified) (one case), textile dyes (unspecified) (one case), and PPD (one case).

Three cases of facemask-related ACD were reported, with two being caused by IPPD and one by nickel. There were two cases of headgear-associated contact allergy, one of which was attributable to a disperse dye (unspecified) in ear defenders. The number of cases and incidence rates (per 100 000 employed) of non-glove PPE-related dermatoses by industry are summarized in Table 2.

The most frequently reported occupations were protective service occupations, including police officers, fire service officers and prison service officers (25 cases), nurses (21 cases), and process operatives (18 cases). Annual average incidence rates (per 100 000 employed) were 1.2 for protective service occupations (95% CI: 0.5-1.9), 0.45 for nurses (95% CI: 0.19-0.71), and 0.85 for process

TABLE 1 Types of non-glove personal protective equipment (PPE) associated with dermatoses

PPE	ACD	ICD	Friction	Occlusion	Acne	Infections	CU
Footwear	49	4	5	6	0	2	1
Clothing	34	23	9	7	0	1	0
Facemasks/safety glasses	4	1	2	2	4	0	0
Headgear	2	3	6	4	1	0	0
Unknown	1	0	0	0	1	0	0
Total ^a	92 (47.4%)	31 (16.0%)	22 (11.3%)	22 (11.3%)	6 (3.1%)	3 (1.5%)	1 (0.52%)

Abbreviations: ACD, allergic contact dermatitis; CU, contact urticaria; ICD, irritant contact dermatitis.

^a Unspecified dermatitis (17 cases) was excluded.

TABLE 2 Actual and estimated cases, and annual average incidence rates (per 100 000 employed), of non-glove personal protective equipment-related dermatoses by industry

Industry (including average size)	Number of cases (1993-2013)		Average annual incidence rate ^a (1996-2013) per 100 000 employed (95% confidence intervals)
	Actual	Estimated	
Agriculture, hunting, forestry, and fishing (391 105)	4	4	NR
Mining and quarrying (105 052)	3	3	NR
Manufacturing (3 895 184)	36	80	0.29 (0.17-0.41)
Electricity, gas and water supply (278 088)	3	3	NR
Construction (2 048 921)	5	16	NR
Wholesale and retail trade (4 169 035)	8	19	0.07 (0.02-0.12)
Hotels and restaurants (1 274 200)	4	4	NR
Transport, storage, and communication (1 828 767)	19	41	0.28 (0.14-0.41)
Financial intermediation (1 189 570)	1	1	NR
Real estate, renting, and business activities (3 247 680)	4	15	NR
Public administration and defence (1 863 666)	33	66	0.33 (0.17-0.48)
Education (2 573 923)	1	1	NR
Health and social work (3 342 479)	30	41	0.14 (0.08-0.20)
Other community, social and personal service activities (1 520 668)	4	15	NR
Not recorded ^b	39	50	NR
Total	194	359	0.14 (0.1-0.17)

NR, not recorded.

^a Incidence rates calculated for industries with five or more actual cases (1996-2013).^b The majority of these 39 cases (38) were reported during the EPIDERM pilot period (1993-1995) when information on industry was not collected.

operatives (95% CI: 0.29-1.42). Table 3 summarizes the causes of non-glove PPE-associated dermatoses/causes of dermatoses by industry.

4 | DISCUSSION

To the best of our knowledge, the incidence and characteristics of non-glove PPE-related dermatoses have not previously been investigated. Our findings show that 9.2% of PPE-related dermatoses in the United Kingdom are not related to gloves. The types of non-glove PPE implicated in occupational skin disease were footwear, clothing, facemasks/safety glasses, and headgear (in order of decreasing frequency). The industries most frequently associated with glove-related dermatoses include healthcare, cleaning, the motor trade, and hairdressing.⁷ In our

study, public administration and defence had the highest annual incidence of non-glove PPE-related dermatoses at (0.33/100 000 employed), followed by manufacturing (0.29/100 000 employed), and transport, storage, and communication (0.28/100 000 employed).

4.1 | Allergic contact dermatitis

As with glove-related occupational skin disease, ACD accounted for the majority of cases of non-glove PPE-related dermatoses.² Patch testing is an essential investigation in patients with dermatitis suspected to be attributable to non-glove PPE. Footwear and clothing were the most common causes of non-glove PPE-related ACD. Headgear and facemasks accounted for fewer cases of ACD. This may be because headgear and facemasks are worn less frequently or are only worn for a short period of time. Although ACD has been described before in association with facemasks, it has not been reported with ear defenders.⁸ Dyes were more frequently associated with clothing-related ACD (58.8%), whereas rubber was the most frequent exposure associated with footwear-related ACD (44.9%). This highlights the varying exposures between clothing and footwear dermatitis.

Geier et al retrospectively analysed the allergen pattern in patients with occupational contact dermatitis caused by rubber gloves. Thiurams were the most frequent allergens identified.^{7,9} Our findings were similar, with thiurams being the most commonly observed allergens in patients with non-glove PPE-related ACD. Other allergens associated with personal protective footwear and clothing-related ACD included mercapto mix and carba mix in rubber, azo dyes in textiles, formaldehyde resins in fabric finish, chromate in leather, and nickel in the toecaps of protective boots. These are similar to the allergens reported in footwear¹⁰ and clothing dermatitis¹¹ in a non-occupational context. There were two cases of diethylthiourea causing ACD in people wearing neoprene wet suits as part of their occupation, for example, swimming coaches. The allergen previously associated with facemask contact allergy was nickel.⁸ In our study, the allergens were IPPD and nickel.

Products made of solid materials (such as non-glove PPE) usually lack information on their allergen content, which can give rise to difficulties in diagnosing ACD. We would urge manufacturers to improve the ingredient labelling of such equipment.

4.2 | Irritant contact dermatitis

In contrast to the findings of previous studies,² ACD accounted for a higher proportion (47.4%) than ICD (16.0%) of non-glove PPE-related dermatoses. PPE is often used as a measure to protect against irritants, and this may explain the lower proportion of ICD seen in our study. Clothing PPE was most frequently responsible for ICD. Our findings show a proportionately higher incidence of folliculitis/acne and frictional and occlusional dermatoses than of glove-related reactions.¹²

4.3 | Acne

Acne is well documented in an occupational setting. Oil acne, coal tar acne, acne cosmetica, acne aestivalis, acne mechanica, tropical acne and chloracne are the subtypes associated with workplace-related

TABLE 3 Actual cases of non-glove personal protective equipment-related dermatoses by industry and diagnosis

Industry ^a	Acne	Friction	Occlusion	Infections	ACD	ICD	Unspecified dermatitis	Total
Agriculture, hunting, forestry, and fishing	0	0	0	0	2	2	0	4
Mining and quarrying	0	0	0	0	2	1	0	3
Manufacturing	0	2	5	0	19	8	2	36
Electricity, gas and water supply	0	1	1	0	1	0	0	3
Construction	0	1	0	1	3	0	0	5
Wholesale and retail trade	0	0	0	0	6	1	1	8
Hotels and restaurants	0	0	0	0	3	0	1	4
Transport, storage, and communication	1	1	0	0	11	5	1	19
Financial intermediation	0	0	0	0	1	0	0	1
Real estate, renting and business activities	0	0	0	0	4	0	0	4
Public administration and defence	3	14	9	0	4	2	1	33
Education	0	0	0	0	1	0	0	1
Health and social work	1	1	2	0	17	8	1	30
Other community, social and personal service activities	0	1	0	0	2	1	0	4

Abbreviations: ACD, allergic contact dermatitis; ICD, irritant contact dermatitis.

^a Information on industry was not recorded for 39 (actual) cases.

exposures.¹³ In our study, acne mechanica was the most common subtype, and was associated with occupations such as catering, the armed forces, manufacturing, and healthcare. Acne mechanica occurs when pressure and friction on dependent areas caused by tight-fitting equipment induces rupture of microcomedones, thereby causing an acneiform eruption. Prolonged pressure can result in significant inflammation. Acne mechanica is known to be associated with headgear and facemasks, as was the case in our study.¹³ We suggest that the provision of headgear and facemasks that are not too tight-fitting and adequate breaks may result in improvement of acne. Moreover, regular skin washing and cleansing agents have been suggested to help.¹³

4.4 | Friction and occlusion

Although the skin has some flexibility enabling it to resist mechanical trauma, excessive friction can affect the integrity of the skin and lead to dermatoses.¹³ A range of factors, including the material used and repetitive forces during the wearing of PPE, may lead to frictional and occlusal dermatoses. The occupations most associated with dermatoses caused by friction and occlusion included those in which there is a requirement to wear uniform, overalls, boots, and helmets, such as the armed forces, engineering, or the building industry. Regular mandatory training for users in these industries on how to put on and wear PPE may help to prevent this. We suggest that the use of materials with lower shearing forces, which are more "breathable," may help to reduce occlusion and frictional dermatoses.

4.5 | Infection

Non-glove PPE, in particular footwear, provides a warm, moist environment for the human papilloma virus (HPV). Furthermore, frictional forces associated with personal protective footwear increase the risk of abrasions, thereby allowing entry of HPV, and subsequently leading to the development of warts. This would explain why all cases of infection in our study were warts mostly associated with footwear.

4.6 | General aspects

One of the strengths of our study is the relatively long period (two decades) of prospective and systematic data collection from a large proportion of UK dermatologists. It showed small numbers of dermatoses associated with non-glove PPE, but documented for the first time the magnitude and main determinants of this comorbidity.

It is unclear whether there were changing trends of allergens associated with non-glove PPE within this period, as the small numbers within the study precluded trend analysis. In addition, it is important to note that any trend of PPE-related allergens will probably vary in the future, as with the decreasing incidence of latex allergy with the introduction of non-latex gloves. Moreover, our results may not be applicable in other countries, owing to varying guidelines and regulations for the use of PPE. Further research is needed to establish whether our findings are reproducible internationally.

The dermatoses associated with non-glove PPE account for 0.84% of occupational skin disease. Data such as ours can help to balance the benefits and risks of measures intended to reduce ill-health and injury. Similar considerations have been applied to the use of gloves and hand hygiene.^{4,6} Identification of the causal agents implicated may also help in making products safer. For example, if dyes used simply for aesthetic purposes cause ill-health, then it would be sensible to remove these altogether from the manufacture of the product. We wish to emphasize to clinicians that, although PPE may be in place to prevent harm from occupational exposures, it can result in significant skin-related comorbidities. This should be borne in mind when patients who use PPE are assessed.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to report.

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