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THE EPIDEMIOLOGY OF OCCUPATIONAL CONTACT DERMATITIS

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Occupational dermatology is the facet of dermatology that deals with skin diseases whose etiology or aggravation is related to some exposure in the workplace. By its nature, occupational dermatology is also related to occupational and preventive medicine. The ideal role of a medical practitioner involved in occupational dermatology is not only to diagnose and treat patients, but also to determine the etiology of the occupational skin disease and to make recommendations for its prevention. Making the diagnosis and offering treatment, determining etiology, and recommending preventive measures are difficult undertakings. Understanding the epidemiology of occupational skin diseases, that is, knowing the distribution and determinants of disease frequency, can assist in accomplishing these tasks.

Occupational dermatology covers a wide variety of skin diseases, including dermatitis, pigmentary disorders, infections, and skin cancer. Many references on occupational skin disorders are available.[2, 23, 32] Because epidemiologic data show that contact dermatitis makes up 90% to 95% of all occupational skin diseases,[10, 20, 27, 35] this entity is emphasized in this article. Occupational contact dermatitis (OCD) is a dermatitis that results from skin contact with an agent found in a workplace setting. The dermatitis can be clinically evident as an acute, subacute, or chronic condition. It can be further classified as an irritant contact dermatitis (ICD) or an allergic contact dermatitis (ACD), which is a type IV, delayed or cell-mediated, immune reaction. Complete reviews of ICD and ACD are available in other sources.[2, 19, 32, 54]

EPIDEMIOLOGIC DATA AND LIMITATIONS

Epidemiologic studies can be categorized as descriptive studies, etiologic studies, and intervention studies.[66] Descriptive studies characterize the demographics of the affected population, identify hazards and risks, and allow for the setting of public health priorities. Etiologic studies examine risk factors and the natural history of disease. Intervention studies evaluate the effectiveness of measures to prevent or reduce the impact of disease and examine the success of therapies.

Occupational epidemiology is concerned with the effects of workplace exposures on the frequency and distribution of diseases and injuries in the population. It deals with acute exposures causing workplace disease outbreaks, such as an epidemic of dermatitis,

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as well as cumulative exposures causing delayed health effects, such as occupational cancers. Occupational epidemiology uses the tools of general epidemiology but has its own distinct features. These features include the emphasis on exposure classification and risk assessment, and the uniqueness of the working population. Many references on general and occupational epidemiology are available.[4, 12, 28, 31, 52]

Epidemiologic data related to OCD come from a variety of sources (Table 1). The information from these sources may provide answers to the following clinically important questions: What is the public health importance and impact of OCD? What information is available on prevalence and incidence? Who is at risk? What industries are associated with a higher risk for workers? What are the occupational exposures causing OCD? What is the prognosis of patients with OCD? What preventive measures and interventions are effective?

It can be difficult to obtain accurate epidemiologic data for OCD, and all sources have their limitations. First of all, though a case definition is a prerequisite for the gathering of epidemiologic data, there is no standard case definition for OCD. In OCD the case definition can vary from one data source to another and may be based on employer reporting, employee self-reporting, patch test results, workers' compensation claims, or clinical diagnosis.

Table 1. OCCUPATIONAL CONTACT DERMATITIS: EXAMPLES OF SOURCES OF EPIDEMIOLOGIC INFORMATION

Source	Type of Data
Bureau of Labor Statistics Annual Survey	National data, survey of private sector employer reports (OSHA 200 logs), annual since 1972
National Health Interview Survey, Occupational Health Supplement	National data, interview survey of US households, Occupational Health Supplement only in 1988
Workers' compensation system	State-based data, interstate variability
Workplace investigations (published literature, NIOSH health hazard evaluations)	Industry- or plant-specific data
Clinical investigations	Clinic- or patch test–based data on patient population
Clinical case studies	Patient-based

The accuracy of the diagnosis is related to the skill level, experience, and knowledge of the medical professional who makes the diagnosis and confirms the relationship with a workplace exposure. Guidelines are available for assessing the work-relatedness of dermatitis,[36] but even with guidelines the diagnosis may be difficult. The diagnosis is based on the medical and occupational histories and physical findings. The OCD empirical induction time,[12] the period from exposure to disease manifestation, is relatively short compared with other chronic occupational diseases. Therefore, the importance of the patient's history of exposures and disease onset is clear. In ICD there are no additional confirmatory tests. Patch tests or provocation tests are discouraged because of a high false-positive rate. In many instances ACD can be confirmed by skin patch tests using specific standardized allergens or, in some circumstances, by provocation tests with nonirritating dilutions of industrial contactants.[19] Patch testing is less than the ideal gold standard; its sensitivity and specificity are approximately 70%, with a 50% relevance for positive tests (ie, in half the cases the chemical inducing a patch test response can be established as the cause of the patient's present or past skin condition).[46] The lack of a standard case definition and the difficulty of diagnosis lead to potential misclassification of OCD, resulting in overestimation or underestimation of disease frequency.

There are other problems in assessing the epidemiology of OCD:

1. Except in states where all occupational diseases are reportable, OCD is not a reportable disease, and so most health department data sources are unuseable for disease monitoring.
2. OCD is not a disease that commonly leads to mortality or hospitalization; thus, death certificates or hospital records are not useful data sources.
3. OCD is a disease seen and treated (though not always specifically diagnosed) by medical professionals in multiple specialties, making review of physician-based data sources inefficient.
4. OCD is a disease that often goes untreated and undiagnosed; thus, many cases may never be documented in any data source.

5. Once a diagnosis of OCD is made, a case does not necessarily elicit a public health response.
6. Individuals with OCD who seek medical care may be a unique subset of the population. Because of self-selection bias, the information obtained may not reflect the epidemiology of the disease in the general working population.
7. Unique exposures may occur in different populations and different industries, making the epidemiology of the disease in one population not necessarily generalizable to other populations.
8. Exposures change with time, and the affected worker may continue to have disease yet no longer be exposed to the causative agent. The evaluation of past exposures may be exceedingly difficult, often relying on historical records, job descriptions, or employee recollection. The latter is subject to recall and information bias.
9. Cross-sectional studies of workers, a common epidemiologic study design, are subject to survivor bias. Those with severe skin disease often leave the workforce, leaving only those who are less affected or not susceptible to disease to be included in the studies.
10. As in epidemiologic studies of other diseases, the epidemiologic terms used in the published literature on OCD are sometimes used incorrectly (eg, the term *incidence* is all too often used to describe prevalence). The reader should evaluate the epidemiologic literature with a discerning eye.

Despite the difficulties, it is important for physicians, epidemiologists, and public health officials to obtain epidemiologic data for OCD. OCD is a preventable disease[53] and only through the knowledge of its distribution and determinants will the goal of prevention be achieved.

PUBLIC HEALTH IMPORTANCE

The public health importance of a disease can be measured several ways, using statistical, clinical, and economic measures. These measures include the absolute number of cases, the incidence rate, the point prevalence rate, the period prevalence rate, the prognosis and preventability of the disease, and the economic impact of the disease.

A review of prevalence studies for eczema due to all causes conducted in six countries showed point prevalence rates of 1.7% to 6.3%, and 1- to 3-year period prevalence rates of 6.2% to 10.6%.[14] Specific national occupational disease and illness data are available from the United States Bureau of Labor Statistics (BLS). The BLS conducts annual surveys of approximately 250,000 employers, selected to represent all private industries in the United States.[8] The goal is to ascertain the total numbers and incidence rates of occupational injuries and illnesses. The survey results are then projected to estimate the numbers and incidence rates of injuries and illnesses in the American working population. All occupational skin diseases or disorders, including OCD, are tabulated in this survey. Information about OCD in particular can be extrapolated from the BLS tabulations (eg, OCD constitutes 90%–95% of all occupational skin diseases[10, 20, 27, 35]; ICD constitutes approximately 80% of OCD cases[11, 21]). BLS data are limited in that they exclude self-employed individuals, small farms, and government agencies; depend on misinterpretable definitions of reportable occupational injuries and illnesses; rely to a large extent on employees reporting conditions to the employer; and do not provide information on the etiology of the skin disease.[38, 39, 43, 62]

BLS data show that skin diseases accounted for a consistent 30% to 45% of all cases of occupational illnesses through the mid 1980s (Fig. 1).[8] A decline in this proportion since 1986 may be partially related to a marked increase in the reporting of disorders associated with repeated trauma. From 1988 to 1990, a register of New Jersey public employees showed that 36% to 41% of all reported occupational illnesses were occupational skin diseases or disorders.[51] Occupational skin diseases, as a percentage of all registered occupational diseases in six different countries, ranged from a low of 13% in Sweden to a high of 34% in the United States.[14]

In 1991, BLS data estimated 58,200 cases of occupational skin diseases or disorders in the US workforce (see Fig. 1).[8] Because of BLS survey limitations, however, it has been estimated that the number of actual occupational skin diseases may be on the order of 10 to 50 times higher than reported by the BLS.[33, 43] This would potentially raise the number of occupational skin disease cases to between 0.5 and 2.9 million per year. BLS data showed

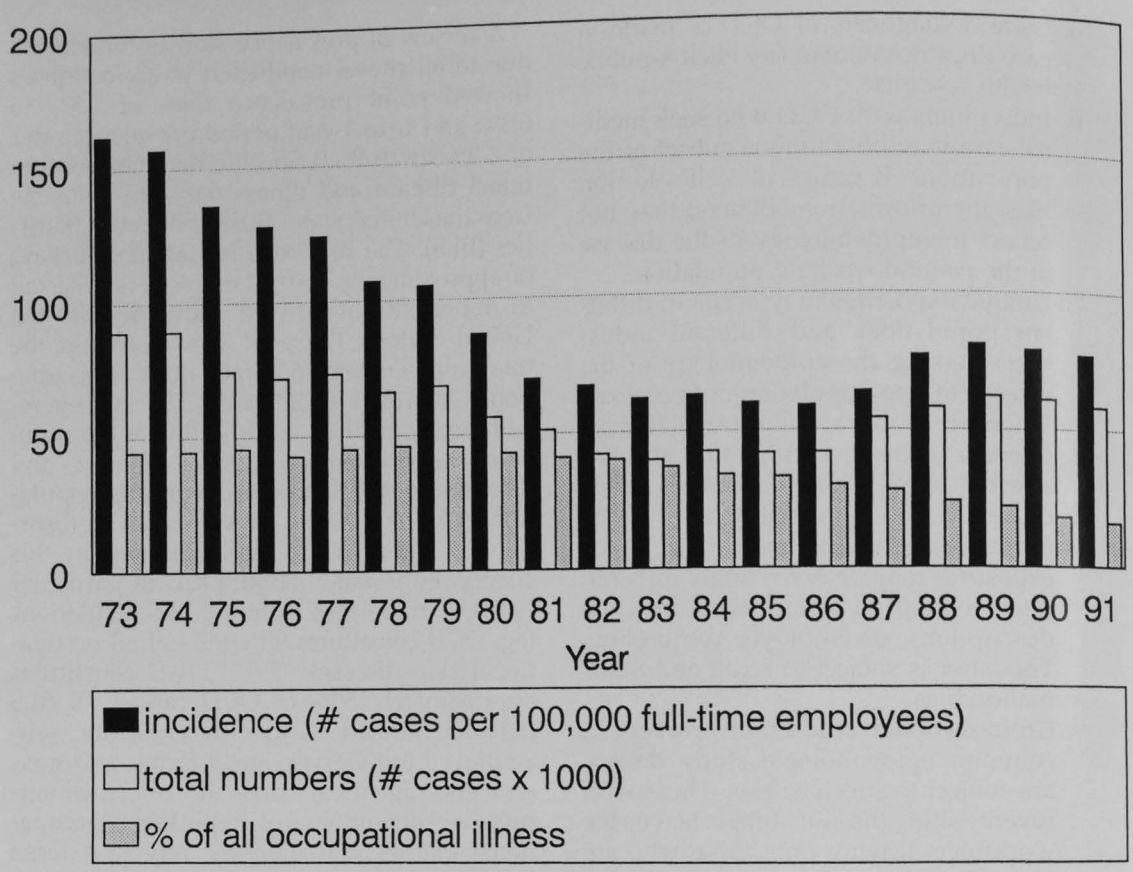

Figure 1. Occupational skin diseases or disorders—Bureau of Labor Statistics annual survey 1973–1991. (*Data from* Occupational Injuries and Illnesses. Washington, D.C., US Department of Labor, Bureau of Labor Statistics.)

an annual incidence rate of 77 cases per 100,000 workers in 1991 (see Fig. 1).[8] The incidence of occupational skin diseases in several countries is similar, with a range of 50 to 70 cases per 100,000 workers per year.[14]

In 1988, the National Health Interview Survey (NHIS) included an Occupational Health Supplement. The survey consisted of personal interviews of randomly selected households. Because there was no further confirmation or validation of reports of OCD, the sensitivity and specificity of self-reported conditions in such a survey are questionable. One study showed that the self-reporting of current skin conditions in a questionnaire had a sensitivity of 31% and a specificity of 94%.[40] For 30,074 people participating in the NHIS, the period prevalence rate was 1.7% for OCD occurring in the preceding year. Projecting these results to the US working population resulted in an estimate of 1.87 million people with OCD and a period prevalence of 1700 per 100,000 workers for the year.[7]

Using workers' compensation (WC) data one may calculate the number of claims per number of eligible workers (the "claims rate"). Under the assumption that claims filed are new cases for the period under study, the claims rate could be considered an incidence rate.[39] An analysis of WC claims reported an average annual claims rate for occupational skin diseases of 24 per 100,000 employees for Ohio (1980–1984),[39] and a rate of 108 per 100,000 employees for South Carolina (1978–1979).[27] A similar retrospective analysis of Oregon WC files (1988–1992) showed an annual claims rate for OCD of 12 per 100,000 eligible workers.[50] Selection bias prohibits these data from being generalizable to the US working population because not all workers are covered by WC and not all workers seek compensation for work-related illnesses. In addition, data from different states are not comparable because WC systems, worker eligibility, and case definitions for compensable illnesses vary. It is also important to stress that the numbers and rates in the BLS survey, NHIS survey, and WC data are not directly

comparable because they rely on different information sources and case definitions.

Studies of dermatology or occupational health clinic populations can measure the proportion of occupational skin disease cases in the clinic population or a prevalence rate. A 1984 to 1985 study of 1199 patients referred for patch testing revealed that 5.9% appeared to have work-related dermatitis,[61] whereas a similar study conducted in 1985 to 1987 showed that of 1579 patients, 18.2% had OCD.[47] In Singapore, of 721 patients seen with hand eczema at a contact dermatitis clinic over 2 years, 31% were diagnosed with occupational eczema.[21] Of 496 Scottish patients referred to a patch test clinic, 14% had OCD.[64] Of 200 Canadians referred to a clinic for contact dermatitis, 94 had positive patch test results of whom 23% had OCD.[45] A 10-year study of 9765 patch test clinic patients in Belgium showed that 22% had OCD along with other dermatitis, and 11% had OCD alone.[16] Such clinical data cannot be interpreted as general population data because of selection bias, referral bias, and local differences in industrial exposures.

The economic impact of a disease can be measured by the direct costs of medical care and WC or disability payments, and the indirect costs associated with lost workdays and loss of productivity. An analysis of 1984 US occupational skin disease data estimated annual medical costs of over $4.7 million ($67 per case) and WC claim awards of over $6.3 million ($1590 per case).[33] In several studies, a consistent 20% to 25% of the workers with occupational skin diseases lost time from work, staying out an average of 9 to 11 days per lost workday case.[8, 10, 27, 65] Based on these data, the estimated annual indirect cost of lost productivity due to occupational skin diseases in 1984 was $11 million ($700 per case).[33] In 1984 the estimated annual direct and indirect costs exceeded $22 million. Considering that the actual annual incidence figures may be 10 to 50 times greater than reported in the BLS data, however, the total annual cost of occupational skin diseases may range from $222 million to $1 billion.[33] These estimates do not include costs of occupational retraining or costs attributable to the effects on the quality of life.

Over the years there have been changes in the epidemiology of occupational skin diseases. The downtrend seen in Figure 1 may be attributable to several factors: changes in industry and industrial practices, increased awareness and preventive measures, possible underreporting, underrecognition, and misclassification.[62] Still, the data do point out that OCD is a relatively common disease with a noteworthy economic impact. These factors along with the potential chronicity of the disorder (see Prognosis), its effect on an individual's vocational and avocational activities, and the fact that it is preventable make OCD a disease of public health importance.

POPULATION AT RISK

Information on general ICD and ACD risk factors is helpful to delineate risk factors and susceptibilities for OCD. Overall, the major risk factor for any contact dermatitis is an exposure to an irritant or a sensitizer. In terms of ICD, there are age-associated changes in the skin that can alter the skin's response to irritants. The epidemiology as it relates to age is not well characterized. Racial characteristics may play a role, with black skin possibly being more resistant to irritant reactions than white skin.[5] As for gender differences, in some studies skin irritation of the upper extremity is more often found in women than in men.[30, 41] Genetic factors also play a role in the development of ICD, as shown in studies with monozygotic twins.[25] Finally, other skin diseases, such as atopic dermatitis, may predispose an individual to develop ICD.[20, 55–57] Environmental factors such as heat, cold, and humidity extremes may have a similar effect.[59]

Many factors play a role in ACD, including factors related to the individual, the allergen, and the environment. As in ICD, the individual factors include age, gender, and genetic predisposition. Preexisting irritant dermatitis results in a breakdown of the epidermal barrier and allows for sensitization to develop more readily.[18] Unlike ICD, however, individuals with atopic dermatitis are not more likely to develop ACD.[55, 57]

Specific data on occupational skin disease show that atopy is an important risk factor. One study noted a relative risk for developing occupational skin disease of 13.5 in atopic individuals when compared with nonatopic individuals.[58] In a prospective study of hand eczema in over 2400 newly employed hospital workers, in which the data were analyzed by logistic regression, a history of atopic dermatitis had an odds ratio of three (those with atopic dermatitis were three times

as likely as those without atopic dermatitis to develop hand eczema).[48] In a Belgian study, 32% of the patients with OCD had a personal or family atopic history.[16] In addition, other inflammatory skin diseases may increase one's susceptibility to OCD or be aggravated by workplace exposures.[1]

It is difficult to interpret reported gender and age differences in OCD and general contact dermatitis. A cross-sectional study, in which 3140 individuals underwent skin examinations of the hands and arms, was conducted in the Netherlands.[13] In this study, the prevalence of eczema, which included ICD and ACD, was 4.6% in men and 8.0% in women. In over 1700 patients referred to an occupational dermatology service, 66% were men and 34% were women.[20] Of 496 Scottish patients referred to a patch test clinic, 17% of the men and 12% of the women had OCD.[64] Of 94 patients in Canada who tested positively in skin patch tests, 41% of the men had OCD, whereas 8.6% of the women had OCD.[45] In a patch test study of 1579 patients, in which the data were analyzed by logistic regression, male gender had an odds ratio of 1.6 (1.6 times as likely as women to have OCD), and individuals below 40 years of age had an odds ratio of 2.5 (2.5 times as likely as those over 40 to have OCD).[47] In the 1988 NHIS, for those reporting OCD, there was no difference in prevalence when the group was stratified by gender.[7] Age and gender are often associated with both the exposure and the disease, and therefore may be confounders of the association of OCD with a specific workplace exposure. Some investigators do not consider either age or gender independent risk factors for contact dermatitis.[14]

Epidemiologic data show that OCD has a particular anatomic distribution, with the hands and the face being the most common sites.[64] Approximately 80% of OCD cases have hand involvement,[16, 47] and 10% have involvement of the face.[47]

There are myriad occupations that have unique exposures that result in OCD. Many of these are well described in the literature.[3, 32] Total numbers and incidence rates of occupational dermatologic conditions by major industry division are listed in Table 2. The greatest number of cases of occupational skin diseases is seen in manufacturing, but the highest incidence rate is seen in agriculture. More specific industrial activities with high incidence rates of skin diseases or disorders are listed in Table 3. In addition, high incidence rates have been noted in industries involved with the following goods and services: landscaping and horticulture, poultry dressing and processing, fresh and frozen packaged fish, beet sugar, surface active agents and penetrants, adhesives and sealants, and abrasive products.[35, 38] In a patch test clinic study of over 9700 patients in Belgium, the most commonly affected occupational groups included mechanics, housekeepers, metal workers, cleaners, paramedical personnel, office workers, cement workers, hairdressers and beauticians, bakers, and cooks.[16] Blue collar and self-employed workers were the predominant group with work-related dermatitis.[16] In the NHIS, the occupational groups with the highest prevalence of self-reported OCD included physicians, dentists, nurses, pharmacists, dieticians (5.6%); public transport attendants, cosmetologists, other personal service occupations (4.9%); health care

Table 2. OCCUPATIONAL SKIN DISEASES OR DISORDERS, BUREAU OF LABOR STATISTICS ANNUAL SURVEY, 1991: NUMBERS AND INCIDENCE RATES BY MAJOR INDUSTRY

Major Industry	Total No. of Cases	Incidence (No. of Cases per 100,000 Full-time Employees)
Agriculture/forestry/fish	3600	345
Manufacturing	31,800	179
Services	12,600	60
Construction	2200	56
Transport/utilities	2800	53
Mining	200	29
Wholesale/retail trade	4400	23
Finance/insurance/realty	600	10
Total	58,200	77

Data from Occupational Injuries and Illnesses in the United States, 1991. US Department of Labor, Bureau of Labor Statistics, Bulletin 2424, May 1993.

Table 3. OCCUPATIONAL SKIN DISEASES OR DISORDERS, BUREAU OF LABOR STATISTICS ANNUAL SURVEY, 1991: INCIDENCE RATES BY SPECIFIC INDUSTRY

Specific Industry	Incidence (No. of Cases per 100,000 Full-time Employees)
Forestry	1365
Meat products	778
Leather tanning and finishing	612
Motor vehicles and equipment	548
Motorcycles, bicycles, and parts	487
Ophthalmic goods	423
Railroad equipment	400
Ordnance and accessories	396
Cutlery, handtools, and hardware	395
Engines and turbines	382
Screw machine products, bolts, etc.	333
Agricultural services	332
Agricultural production	329
Aircraft and parts	312
Paints and allied products	310

Data from Occupational Injuries and Illnesses in the United States, 1991. US Department of Labor, Bureau of Labor Statistics, Bulletin 2424, May 1993.

therapists, technologists, technicians, assistants (3.5%); and mechanics and repairers of vehicles, engines, heavy equipment, and machinery (3.5%).[7] In a cross-sectional study comparing the prevalence of hand dermatitis in several occupations with that of the general population, significantly elevated prevalence ratios were found in nurses, manual workers in a chemical company, workers in an electric company, and public works employees.[60] Of all accepted WC claims for OCD in Oregon, the common occupations and activities were laborers (14.2%), food service (13.8%), machine operators (13.1%), agriculture (9.0%), health professionals (8.2%), and janitors/maids (6.4%), followed by production crafts, mechanics, construction, and hairdressers/cosmetologists.[50] The type of work environment also plays a role, including factors such as heat, cold, humidity, and wet work.[59] In hospital workers, employees involved with wet work were twice as likely to develop hand eczema compared with workers in an office environment.[48]

ETIOLOGIC AGENTS

Extensive lists of irritants and allergens are available in reference books.[2, 19] The most frequent causes of ICD include soaps and detergents, fiberglass and particulate dusts, food products, cleaning agents, solvents, plastics and resins, petroleum products and lubricants, metals, and machine oils and coolants.[35, 37] Causes of ACD include metallic salts, organic dyes, plants, plastic resins, rubber additives, and germicides.[37]

In 5046 patch-tested patients, the most common allergens were nickel, thimerosal, neomycin, formaldehyde, paraphenylenediamine, quaternium-15, thiuram mix, balsam of Peru, cinnamic alcohol, ethylenediamine, cinnamic aldehyde, carba mix, mercapto mix, and potassium dichromate.[47] In patients with OCD, the common allergens included mercapto mix, mercaptobenzothiazole, rosin, thiuram, paraphenylenediamine, and epoxy resin.[47] In a Belgian study of over 2000 patients with OCD, the most frequent allergens were nickel, chromate, paraphenylenediamine dihydrochloride, cobalt, epoxy resin, thiuram derivatives, and black rubber mix.[16]

PROGNOSIS

Studies investigating the prognosis for OCD are limited. Of patients with OCD followed over a 3- to 10-year period, only 25% had complete healing of dermatitis, whereas approximately 75% had chronic eczema or recurrences of dermatitis.[9, 20, 22] Outcomes may or may not be influenced by a change in occupation away from the dermatitis-provoking job.[20, 22] Studies are contradictory about whether ACD or ICD has a better prognosis.[20, 24] In general, patients with OCD have a poor prognosis for clearing their condition, making the primary prevention of OCD all the more important.[15, 24]

PREVENTION

Strategies in the prevention of OCD include identifying allergens and irritants; substituting chemicals that are less irritating or allergenic; establishing engineering controls to reduce exposure; using personal protective equipment such as gloves and special clothing; using barrier creams; emphasizing personal and occupational hygiene; establishing educational programs to increase awareness in the workplace; and providing health screening.[35, 37, 44] Chemical changes have

proved to be beneficial. The addition of ferrous sulfate to cement to reduce the chromate content was effective in reducing OCD in Europe. The prevalence of chromate allergy in cement workers had fallen from 11% to 3% over a 6-year period during which this intervention occurred.[6] The introduction of personal protective equipment must be considered carefully because it may actually create problems by occluding allergens or irritants or by directly irritating the skin. Similarly, the excessive pursuit of personal hygiene in the workplace may actually lead to misuse of soaps and detergents and result in ICD.[34] The effectiveness of gloves depends on the specific exposures and the types of gloves used. Among solderers in the electronics industry, glove use decreased the period prevalence rate of work-related skin rashes from 15.4% to 3.4%.[29] The effectiveness of barrier creams is controversial,[49] and in some circumstances workers using barrier creams may have higher prevalence rates of OCD than those who do not use the creams.[63] Other interventions, which included providing advice on personal protective equipment and educating the workforce about skin care and exposures, were beneficial for workers constructing the English Channel tunnel.[26]

CONCLUSION

Over half a century ago, J.G. Downing, a Boston dermatologist, noted some of the problems in studying the epidemiology of occupational skin diseases: "Dermatologists have always been cognizant of the deleterious effect of occupational exposure on the skin. . . . To determine accurately the incidence of cutaneous disease in industry is an impossible task, owing to the extremely variable interpretations of statistics and the lack of adequate terminology."[17] There have been some improvements in the epidemiologic study of OCD, but the data remain far from perfect. Downing also emphasized the important role of the dermatologist in working toward the prevention of OCD: ". . . prevention and early detection are much cheaper than indifference and neglect . . . every outbreak should be thoroughly investigated, for the hypersensitive person may constitute the warning signal of a whole series of reactions, and careful study of his condition may be the means of preventing similar eruptions."[17]

The goal of the US Public Health Service for the year 2000, as established in its publication, *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*, is to reduce occupational skin disorders or diseases to an incidence of no more than 55 per 100,000 full-time workers.[42] Information on the prevalence and incidence of OCD, individual and occupational risk factors, etiologic agents, prognosis, and available preventive measures will allow the dermatologist to play a key role in helping to achieve this national goal.

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References

1. Adams RM: High risk dermatoses. J Occup Med 23:829–834, 1981
2. Adams RM: Occupational Skin Disease, ed 2. Philadelphia, WB Saunders, 1990
3. Adams RM: Job descriptions with their irritants and allergens. *In* Adams RM: Occupational Skin Disease, ed 2. Philadelphia, WB Saunders, 1990
4. Ahlbom A, Norell S: Introduction to Modern Epidemiology. Newton Lower Falls, Epidemiology Resources Inc., 1990
5. Andersen KE, Maibach HI: Black and white human skin differences. J Am Acad Dermatol 1:276–282, 1979
6. Avnstorp C: Prevalence of cement eczema in Denmark before and since addition of ferrous sulfate to Danish cement. Acta Derm Venereol (Stockh) 69:151–155, 1989
7. Behrens V, Seligman P, Cameron L, et al: The prevalence of back pain, hand discomfort, and dermatitis in the U.S. working population. Am J Public Health 84:1780–1785, 1994
8. Bureau of Labor Statistics (BLS): Occupational injuries and illnesses in the United States. US Department of Labor, BLS, published annually from 1972 to 1991; data for 1991 published May 1993 in Bulletin 2424
9. Burrows D: Prognosis in industrial dermatitis. Br J Dermatol 87:145–148, 1972
10. California Department of Industrial Relations: Occupational Skin Disease in California. San Francisco, Division of Labor Statistics and Research, 1982
11. Centers for Disease Control: Leading work-related diseases and injuries—Dermatologic conditions. Morbid Mortal Week Rep 35:561–563, 1986
12. Checkoway H, Pearce NE, Crawford-Brown DJ: Research Methods in Occupational Epidemiology. New York, Oxford University Press, 1989
13. Coenraads PJ, Nater JP, Van der Lende R: Prevalence of eczema and other dermatoses of the hands and arms in the Netherlands—Association with age and occupation. Clin Exp Dermatol 8:495–503, 1983
14. Coenraads PJ, Smit J: Epidemiology. *In* Rycroft RJG, Menne T, Frosch PJ, et al (eds): Textbook of Contact Dermatitis. New York, Springer-Verlag, 1992

15. Cooley JE, Nethercott JR: Prognosis of occupational skin disease. *In* Occupational Skin Disease: State of the Art Reviews—Occupational Medicine. Philadelphia, Hanley and Belfus, 1994
16. Dooms-Grossen A, Drieghe J, Dooms M: The computer and occupational skin disease. *In* Adams RM: Occupational Skin Disease, ed 2. Philadelphia, WB Saunders, 1990
17. Downing JG: Cutaneous eruptions among industrial workers—A review of two thousand cases for compensation. Arch Dermatol Syphilol 39:12–32, 1939
18. Epstein WL, Kligman AM: Some factors affecting the reaction of allergic contact dermatitis. J Invest Dermatol 33:231–243, 1959
19. Fisher AA: Contact Dermatitis, ed 3. Philadelphia, Lea & Febiger, 1986
20. Fregert S: Occupational dermatitis in a ten-year material (sic). Contact Dermatitis 1:96–107, 1975
21. Goh CL: An epidemiological comparison between occupational and non-occupational hand eczema. Br J Dermatol 120:77–82, 1989
22. Hellier FF: The prognosis in industrial dermatitis. Br Med J 1:196–198, 1958
23. Hogan DJ: Occupational Skin Disorders. New York, Igaku-Shoin, 1994
24. Hogan DJ, Dannaker CJ, Maibach HI: The prognosis of contact dermatitis. J Am Acad Dermatol 23:300–307, 1990
25. Holst R, Moller H: One hundred twin pairs tested with primary irritants. Br J Dermatol 93:145–149, 1975
26. Irvine C, Pugh CE, Hansen EJ, et al: Cement dermatitis in underground workers during construction of the Channel Tunnel. Occup Med 44:17–23, 1994
27. Keil JE, Shmunes E: The epidemiology of work-related skin disease in South Carolina. Arch Dermatol 119:650–654, 1983
28. Kelsey JF, Thompson WD, Evans AS: Methods in Observational Epidemiology. New York, Oxford University Press, 1986
29. Koh D, Lee S, Chia HP, et al: Skin disorders among hand solderers in the electronics industry. Occup Med 44:24–28, 1994
30. Lantinga H, Nater JP, Coenraads PJ: Prevalence, incidence and course of eczema on the hand and forearm in a sample of the general population. Contact Dermatitis 10:135–139, 1984
31. MacMahon B, Pugh TF: Epidemiology, Principles and Methods. Boston, Little, Brown, 1970
32. Marks JG, DeLeo VA: Contact and Occupational Dermatology. St. Louis, Mosby-Year Book, 1992
33. Mathias CGT: The cost of occupational skin disease. Arch Dermatol 121:332–334, 1985
34. Mathias CGT: Contact dermatitis from use or misuse of soaps, detergents, and cleansers in the workplace. *In* Occupational Skin Disease: State of the Art Reviews—Occupational Medicine. Philadelphia, Hanley and Belfus, 1986
35. Mathias CGT: Occupational dermatoses. J Am Acad Dermatol 6:1107–1114, 1988
36. Mathias CGT: Contact dermatitis and workers' compensation—Criteria for establishing occupational causation and aggravation. J Am Acad Dermatol 20:842–848, 1989
37. Mathias CGT: Prevention of occupational contact dermatitis. J Am Acad Dermatol 23:742–748, 1990
38. Mathias CGT, Morrison JH: Occupational skin disease, United States. Arch Dermatol 124:1519–1524, 1988
39. Mathias CGT, Sinks TH, Seligman PJ, et al: Surveillance of occupational skin disease—A method utilizing workers' compensation claims. Am J Ind Med 17:363–370, 1990
40. McCurdy SA, Wiggins P, Schenker MB: Assessing dermatitis in epidemiologic studies—Occupational skin disease among California grape and tomato harvesters. Am J Ind Med 16:147–157, 1989
41. Meding B, Swanbeck G: Occupational hand eczema in an industrial city. Contact Dermatitis 22:13–23, 1990
42. National Center for Health Statistics: Healthy People 2000 Review, 1992. Hyattsville, US Department of Health and Human Services, DHHS Publication (PHS) 93–1232–1, 1993
43. National Institute for Occupational Safety and Health (NIOSH): National Occupational Survey—Pilot study for development of an occupational disease surveillance method. Rockville, US Department of Health, Education, and Welfare, HEW Publication (NIOSH) 75–162, 1975
44. National Institute for Occupational Safety and Health (NIOSH): Proposed national strategy for the prevention of leading work-related diseases and injuries—Dermatological conditions. Cincinnati, US Department of Health and Human Services, DHHS Publication (NIOSH) 89–136, 1988
45. Nethercott JR: Results of routine patch testing of 200 patients in Toronto, Canada. Contact Dermatitis 8:389–395, 1982
46. Nethercott JR: Practical problems in the use of patch testing in the evaluation of patients with contact dermatitis. Curr Probl Dermatol 2(4), 1990
47. Nethercott JR, Holness DL, Adams RM, et al: Patch testing with a routine screening tray in North America, 1985 through 1989: I-IV. Am J Contact Dermatitis 2–4:122–134, 198–201, 247–254, 1991
48. Nilsson E, Mikaelsson B, Andersson S: Atopy, occupation and domestic work as risk factors for hand eczema in hospital workers. Contact Dermatitis 13:216–223, 1985
49. Orchard S: Barrier creams. Dermatol Clin 2:619–629, 1984
50. Oregon Health Division: A new program to reduce occupational dermatitis in Oregon. CD Summary, Center for Disease Prevention and Epidemiology, Oregon Health Division, 42, No. 21, 1993
51. Roche LM: Use of employer illness reports for occupational disease surveillance among public employees in New Jersey. J Occup Med 35:581–586, 1993
52. Rothman KJ: Modern Epidemiology. Boston, Little, Brown, 1986
53. Rutstein DD, Mullan RJ, Frazier TM, et al: Sentinel health events (occupational)—A basis for physician recognition and public health surveillance. Am J Public Health 73:1054–1062, 1983
54. Rycroft RJG, Menne T, Frosch PJ, et al (eds): Textbook of Contact Dermatitis. New York, Springer-Verlag, 1992
55. Rystedt I: Contact sensitivity in adults with atopic dermatitis in childhood. Contact Dermatitis 13:1–8, 1985
56. Rystedt I: Atopic background in patients with occupational hand eczema. Contact Dermatitis 12:247–254, 1985
57. Rystedt I: The role of atopy in occupational skin disease. *In* Adams RM: Occupational Skin Disease, ed 2. Philadelphia, WB Saunders, 1990
58. Shmunes E, Keil JE: Occupational dermatoses in South Carolina—A descriptive analysis of cost variables. J Am Acad Dermatol 9:861–866, 1983

59. Shmunes E: Predisposing factors in occupational skin diseases. Dermatol Clin 6:7–14, 1988
60. Smit HA, Burdorf A, Coenraads PJ: Prevalence of hand dermatitis in different occupations. Int J Epidemiol 22:288–293, 1993
61. Storrs FJ, Rosenthal LE, Adams RM, et al: Prevalence and relevance of allergic reactions in patients patch tested in North America—1984 to 1985. J Am Acad Dermatol 20:1038–1045, 1989
62. Taylor JS: Occupational disease statistics—in perspective. Arch Dermatol 124:1557–1558, 1988
63. Varigos GA, Dunt DR: Occupational dermatitis—An epidemiological study in the rubber and cement industries. Contact Dermatitis 7:105–110, 1981
64. Vestey JP, Gawkrodger DJ, Wong WK, et al: An analysis of 501 consecutive contact clinic consultations. Contact Dermatitis 15:119–125, 1986
65. Wang CL: Occupational skin disease continues to plague industry. Monthly Labor Review 102:17–22, 1979
66. Wegman DH: The potential impact of epidemiology on the prevention of occupational disease. Am J Public Health 82:944–953, 1992

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