Eonomic Burden of Dermatitis in US Workers

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Objective: To estimate the economic burden associated with dermatitis in those aged 16 to 65 years and working in seven industry sectors (DW). **Methods:** The 2004 Medical Expenditure Panel Survey and the cost-of-illness method, which aggregates health care costs and productivity losses, were used. **Results:** The economic burden of DW was ~$1.2 billion, representing 10.5% of the cost of all skin diseases and disorders (SDD). In all private industry (ie, the sum of the seven sectors examined), cost per employed person was ~$11 for DW and $109 for SDD. In the all-services sector, one of the seven examined, cost per employed person was ~$15 for DW and $113 for SDD. **Conclusions:** This study provides the first published estimate of the economic burden of DW, based on a representative sample of the US population.

Learning Objectives

- Discuss previous estimates of the incidence and costs of dermatitis in the U.S. workforce, including the limitations of the data.
- Summarize the new findings on the economic burden of dermatitis, its contribution to the costs of all skin diseases, and its impact in different industry sectors.
- Discuss the implications for future surveillance of occupational skin diseases and opportunities for prevention.

Dermatitis, a localized inflammation of the skin, usually appears as eruptions, redness, swelling, or pain. Dermatitis is the body's reaction to the injury of skin tissues. Atopic dermatitis (AD) may occur upon exposure to specific antigens, and this reaction may be exacerbated by a hereditary predisposition to allergens such as asthma or hay fever. In addition, contact dermatitis (CD) occurs from touching an irritating substance or allergen. The type and seriousness of the exposure affect the potential for and the intensity of the reaction. Occupational dermatitis—skin inflammation caused by many chemical, biological, and physical hazards found in the workplace—is one of the more common, nontraumatic, occupational illnesses in the United States. Workers' skin can directly or indirectly be exposed to hazardous substances in the workplace. For example, exposure can occur through the use of solvents, the application of pesticides or paints via spraying, the occurrence of accidental spills or splashes, and the handling of or excessive contact with water. Both AD and CD occur in the job environment.

According to the Bureau of Labor Statistics (BLS),[1] 3220 occupational dermatitis cases involving days away from work (DAFW) occurred in 2004. The incidence rate was 0.4 per 10,000 full-time workers. The median DAFW for occupational dermatitis was 4, compared with 7 for all nonfatal injuries and illnesses. BLS collects these data from employers who are required through regulation to report[2] occupational illnesses, including skin disease. Annual BLS data comprise the effects of new exposures manifested as new cases that have been identified by a health care professional as occupational during that calendar year. If these criteria are not met, cases are not reported by BLS. As a result, BLS reports exclude cases persisting over 1 year or occurring intermittently. Recurring cases in the same area of the body may be considered new if there was complete recovery for ~1 day between recurrences. The decision that the recurring case is new can be based on the employer's judgment, with or without medical determination. Employers are not required to report illnesses by age, sex, race, and occupation or the number of days an employee may have returned to work in a different capacity or had been on restricted work activity. Although some employers choose to report this information, accurately identifying occupational skin disease can still be problematic. Some occupational skin exposures are obvious, presenting an immediate acute reaction, with resulting cases easily identified and reported. Often a time lapse between exposure and symptoms occurs, making it difficult to define a case's work relatedness. Also, minor cases are not reported by BLS. For example, a case of work-related skin rash would not be reported unless it resulted in DAFW, restricted work, reassignment to another job, or medical treatment beyond first aid. In addition, if the illness was not clearly recognized or clinically diagnosed, it could have been identified as a minor problem by an employee and treated with over-the-counter remedies, again resulting in the underreporting of skin disease.

A few studies exist on the incidence of cases of occupational dermatitis with DAFW.[3,4] Some of the existing studies rely exclusively on workers' compensation data, such as those from Washington State.[5–11] Although burden estimates based on workers' compensation data are supported by the documentation of claims by physicians, these data mostly focus on injuries and provide a very narrow perspective on illnesses. In addition, no national estimates exist of the burden of dermatitis based on workers' compensation. Such an estimate would be difficult to obtain because workers' compensation laws, data collection, and reimbursement policies vary by state.

There are a few studies on the burden of skin disease[12,13] and three[14–16] on the additional costs to employers or third-party payers for employees and their dependents with AD, a more restrictive category. No studies were found on the cost of occupational skin disease or occupational dermatitis. Therefore, studies published to date do not provide estimates of the costs of dermatitis, both AD and CD, for all workers nor do they break down the burden of these costs by industry sector. Nevertheless, employers, who face competing demands and scarce funds need information on the burden of conditions affecting worker safety and health, including dermatitis, to effectively prioritize their investments in targeted prevention strategies. In addition to employers, policymakers and other stakeholders who make decisions for the allocation of scarce resources also need information on the burden of specific illnesses. Therefore, to guide strategies for prevention, there is a need to estimate these costs from a broad societal perspective. For example, interventions for dermatitis might focus on reducing individual exposure to related hazards and on modifying exposure characteristics. Adaptations may include lessening the exposure to wet work and decreasing the handling of chemicals. Engineering controls and substitutions, both chemical and physical, also may improve workplace environments and

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decrease illness incidence. In addition, explicit behavioral practices or personal protective equipment usage may be instituted by employers, industry, or regulating officials.

The main goal of this study was to determine the economic burden of dermatitis in the US working population aged 16 to 65 years (DW), by industry sector, from the societal perspective. This study used a single source of nationally representative data and provides estimates for DW, for a broad range of skin diseases and disorders (SDD), for a broader skin disease category than SDD (SDD2) that was used in a nonoccupational study,[12] and for CD alone (CDW). These additional estimates were included because SDD2, SDD, and CDW provide two broader and one narrower category, respectively, of illnesses similar to DW and affecting the US working population. This way, the relative magnitude of the burden of DW, compared with the other three illness categories, can be assessed. Estimates are provided of the cost of health care services sought by those working in specific industry sectors and related productivity losses.

METHODS

Theoretical Background

The cost-of-illness (COI) method[17–21] was used to determine the economic burden of the four skin disease groups in question. The COI method can be used to quantify the effect of illness on the entire economy by estimating costs incurred following illness onset. According to this method, individual direct health care costs and indirect costs, or lost productivity, are aggregated to estimate the overall burden of illness for society. Direct expenditures on health care services are expressed as the cost of resources used in supplying health care that would have been used on other goods and services in the absence of illness. These direct health care costs include the cost of visits to health care professionals, hospitalizations, emergency department visits, prescription medications, and medical tests.

While direct costs reflect changes in the consumption of health care, indirect costs reflect lost productivity. These costs are expressed as the value of resources lost as a result of time spent absent from work or being unable to conduct any other usual daily activity because of illness. Indirect costs include lost earnings, lost fringe benefits, and lost household work by ill workers and the value of caregivers' time that is taken away from household work or is spent absent from work to care for ill workers. In monetary terms, indirect costs are expressed as the value of lost work time or lost wages. Note that a person's absence from work does not always mean that the work itself is not performed nor does a person's presence at work mean that this particular person is performing at his or her maximum productive capacity (referred to as "presenteeism").[22]

Data

Data in this analysis were obtained from the 2004 Medical Expenditure Panel Survey (MEPS), Household Component (HC).[23] MEPS is a continuous large-scale survey of the US civilian and noninstitutionalized population that began in 1996. Data are collected from a nationally representative sample of families and individuals, their health care providers, and employers across the United States. MEPS uses a rotating sample design, according to which a new set or panels of households are selected each year and participate in five rounds of interviews over the following 2 years. Questions address types of illness experienced; types, frequency, and expenditures on health care services used as a consequence of the illness; and demographic information through face-to-face interviews with each person in a household.

Theoretical Application

For this analysis, the COI method was used to estimate the total economic burden of SDD2, SDD, DW, and CDW in 2004. Information on fatalities is not collected by MEPS and has not been included in this analysis. Nevertheless, fatalities are rare for skin disease, and because this analysis used data for 1 year, productivity losses to society were not expected to be greatly affected by the omission of fatalities.

Expenditure data from MEPS-HC[23] were used to estimate the total cost of illness for individuals in the four identified skin disease groups. These prevalence-based data allowed the creation of event files that contain information on the case characteristics and related costs for each person seeking treatment for skin disease. Aggregating this information for all cases during 2004 provides the direct cost component of the COI estimate for that year. More specifically, direct costs were estimated using data from separate files on expenses for the following events[23]: health care provider office visits, outpatient hospital visits, emergency department visits, hospitalizations, home health care visits, and prescription medications. Separate event files with specific illness codes and person identification numbers were combined into one person-level event file for each ill worker. This way, if an ill worker had experienced more than one event for a specific illness—eg, a health care provider visit and a prescription for medications—this worker's event file included information on both of these events.

Person-level events were then merged with the consolidated population file[23] to attach additional information on several variables to each person's illness events. These variables included wages, industry of work, missed workdays, and demographic factors such as age and sex. Aggregating this information for all cases during 2004 provided the indirect cost component of the COI estimate for that year. More specifically, indirect costs were calculated from the dollar value of DAFW for each ill worker due to the four specific skin disease groups mentioned earlier and the dollar value of DAFW for family members who cared for an ill worker. Reported hourly wages of ill workers who missed work and their family members who also missed work to care for them were converted into a daily wage for each of these persons. If hourly earnings were not reported but days spent away from work and an industry of work were reported, the average hourly earnings of production for nonsupervisory workers in that industry from the Current Employment Statistics[24] of the BLS were used and, where necessary, defined into the National Institute for Occupational Safety and Health's (NIOSH) National Occupational Research Agenda (NORA)[25] categories. The daily wage was applied to the total number of days an ill worker missed work because of a specific illness to calculate the indirect cost associated with that illness for each ill worker. Wage information was used in a similar way for family members who missed work to care for an ill worker. If family members who missed work to care for an ill worker did not provide information on their industry of work, no indirect costs were calculated for their time.

Data Application

Skin disease categories were defined according to the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM),[26] which are available in MEPS event files. The four skin disease groups used in this study (SDD, SDD2, DW, and CDW) are presented in Table 1, along with their associated ICD-9-CM diagnostic codes.

SDD was selected because it is similar to the BLS definition for skin disorders and diseases. SDD includes several ICD-9-CM codes for illnesses characterized as diseases of the skin and subcutaneous tissue.

SDD2 was the largest group of disease codes used. The SDD2 group was defined by applying the definition used by Dehkharghani et al[12] to MEPS data.

DW included three ICD-9-CM codes for dermatitis in the working population. The definition for DW is comparable to the BLS definition for occupational dermatitis, which NIOSH uses in their *Worker Health Chartbook*.[27]

TABLE 1. Skin Disease Illness Groups by ICD-9-CM Diagnostic Codes

Illness Groups	ICD-9-CM Codes[27]
Dehkharghani et al13 definition (SDD2)	050−057, 173,680−709, and 940−949
All diseases of the skin and subcutaneous tissue (SDD)	680−709
Atopic, contact, and dermatitis due to drugs and substances taken internally (DW)	691−693
Contact dermatitis and other eczema (CDW)	692

Finally, CDW was the only disease included in this study that had a unique code for CD and other eczema. Although CDW has an occupational component, this information is not reported separately in MEPS.

As shown in Table 1, the codes included in SDD comprise a subset of the codes included in SDD2, and, similarly, CDW is one of the codes included in DW.

RESULTS

Event Files and Event Characteristics

Event files[23] from MEPS-HC included the following categories: HC-085G, the 2004 health care provider office visits event file; HC-085A, the 2004 prescription medications event file; HC-085E, the 2004 emergency department visits event file; HC-085F, the 2004 outpatient hospital visits event file; HC-085D, the 2004 hospitalizations event file; and HC-085H, the 2004 home health care visits event file. Events for skin diseases included event identification numbers, person identification numbers, and ICD-9-CM codes.[26] This enabled counting the number of reported events and the number of persons who reported having experienced each event. Information on all events, even those with zero expenditure, was included in this study.

When all events with ICD codes were combined, there were 271,669 events for all illnesses in 2004 (Table 2). These events included health care provider office visits (46.5%), prescription medications (43.6%), outpatient hospital visits (4.9%), home health care visits (1.6%), emergency department visits (2.3%), and hospitalizations (1.2%). CDW and DW each accounted for ∼0.5% of the total number of these events. Approximately 800 persons reported ∼1450 DW-related events, and ∼750 persons reported ∼1300 CDW-related events. This suggests that, on average, nearly, two medical events related to CDW or DW were experienced by each person. SDD and SDD2 each accounted for ∼3% of all events. In other words, slightly ∼3500 persons reported ∼7300 SDD events, and ∼4200 persons reported ∼8900 SDD2 events.

Sample Persons and Other Population Characteristics

To add demographic information, event files were combined with the full year consolidated population MEPS file (HC-089).[23] The consolidated population file originally contained information on 34,403 persons, including age and reported industries in which respondents were employed. The sample was limited to those being aged 16 to 65 years and working in seven specific industry sectors. Industry categories were sorted by their National American Industry Classification System codes[28] to construct the seven industry sectors used in this study. These sectors follow NIOSH's National Occupational Research Agenda[25] format. The industry sectors used were agriculture, forestry, fishing, and hunting (National American Industry Classification System code 11); mining (21); construction (23);

TABLE 2. Sample Events for 2004

	Sample Events for Entire Sample Without Demographic Adjustments		Person-Event After Demographics Combined (Millions)	
Event Type	Reported Event	Reporting Persons	Event	Population Estimate (Millions)
Total	271,669	48,864	14,873	150.8
Total ambulatory visits*	145,593	26,766	8,450	90.03
Office-based medical provider visits	126,380	18,362	6,588	71.48
Emergency room visits	6,284	4,492	1,749	17.49
Outpatient visits	13,289	3,912	113	1.06
Hospital inpatient stays	3,177	2,385	6	0.05
Home health visits	4,214	721	35	0.49
Prescription medicines	118,325	18,992	1,247	13.63
			Reported Illness Events	
Illness Groups	Sample Events Used	Number of Persons Reporting Event	Sample Person With Demographics Combined	Population With Demographics (Millions)
All illnesses	271,669	48,864	14,873	150.80
Dehkharghani et al13 definition (SDD2)	8,892	4,256	1,114	12.66
All diseases of the skin and subcutaneous tissue (SDD)	7,327	3,534	951	10.68
Atopic, contact, and dermatitis due to drugs and substances taken internally (DW)	1,439	838	194	2.23
Contact dermatitis and other eczema (CDW)	1,313	744	185	2.13

*Ambulatory is the sum of office-based, emergency room, and outpatient visits.

TABLE 3. Population Characteristics for 2004

Population Characteristics	Sample Persons	Population, Weighted Persons (Millions)
Total	14,873	150.80
Industry groups		
Agriculture, forestry, fishing	256	1.85
Mining	83*	0.71*
Construction	1,272	12.13
Manufacturing	1,721	16.89
Wholesale and retail trade	2,179	21.47
Transportation, warehousing, utilities	667	7.17
All services	8,695	90.58
Sex		
Male	7,546	78.94
Female	7,327	71.86
Age		
16 to 44 yr	9,578	94.99
16 to 24 yr	2,397	23.6
25 to 34 yr	3,510	34.9
35 to 44 yr	3,671	36.5
45 to 65 yr	5,295	55.81
45 to 54 yr	3,357	34.5
55 to 65 yr	1,938	21.3

*Value is unreliable because sample data do not meet publication guidelines for MEPS. To be valid, the number of event observations should be ≥100.

manufacturing (31 to 33); transportation, warehousing, and utilities (48, 49, 22); wholesale and retail trade (42, 44, 45); and all services (including health care and social assistance [62] and other services [51 to 56, 61, 71, 72, 81, 92]).[28] After both types of files (event files and consolidated population files) were merged and age and industry sector adjustments were made, 14,873 observations remained in the final sample.

Population weighting factors (MEPS variable PERWT04F) were then used to extrapolate the sample information to the entire US population. Applying the weighting factors on the sample of ~15,000 persons resulted in 150.8 million represented persons. The US population was 306.2 million on April 7, 2009.[29] Therefore, approximately one half of the US population was included in the analysis of this report. Approximately 2% of this population had experienced CDW- or DW-related events. In addition, ~11% of this population had experienced SDD-related events and 13% experienced SDD2-related events (Table 2).

The largest industry sector was the all-services sector, accounting for about three fifths of the sample. This sector was followed by wholesale and retail trade, manufacturing, and construction, each accounting for ~9% to 15% of the sample. The sample was divided almost equally between men and women, and approximately seven eighths of the sample included persons who were 16 to 54 years old. Although persons aged 16 to 24 years accounted for only 16% of the sample, most of those employed in the seven sectors used belonged in the 25- to 54-year age group. Each of the latter three age groups (25 to 34, 35 to 44, and 45 to 54 years) accounted for nearly one fourth of the sample. In other words, ~70% of the persons in the sample were aged between 25 and 55 years (Table 3).

Expenditures and Prevalence

Table 4 contains the direct, indirect, and total expenditures for those of working age who reported being employed in any one of the seven industry sectors described earlier. The economic burden of DW was 10.5% of SDD. Both SDD and SDD2 accounted for ~3% each of the cost of all illnesses, and DW and CDW each accounted for ~0.3% of the cost of all illnesses. Direct costs were a substantial component (72%) of total costs for the larger skin disease groups—SDD and SDD2. In contrast, the DW and CDW skin disease groups experienced indirect costs that were greater than direct medical costs by slightly more than half of the total economic burden. Although the indirect costs of CDW and DW were relatively higher than their direct costs, they were approximately one fifth of the indirect costs of SDD and only 2% of the indirect costs of all illnesses. Note that, as mentioned earlier, fatalities are rare for skin disease, not reported in MEPS, and not included in this study.

The total costs reported in Table 4 demonstrate that the cost of CDW represents most of the cost of DW. Therefore, ICD-9-CM codes 691 and 693 make a very small contribution to DW, both in terms of costs and in terms of number of cases. In other words, the cost of AD and dermatitis due to drugs and substances taken internally is a very small portion of the cost of DW, accounting for ~$44 million of the total cost burden and 0.1 million of the total cases. Moreover, the total direct and indirect cost of CDW was 10.1% of the cost of SDD, in support of the small contribution that codes 691 and 693 make (0.4%) to the cost of SDD.

Cost per person of SDD or SDD2 for this population was less than one half that of all illnesses. For CDW and DW, the cost per person was one fourth of the cost per person for all illnesses. These costs per person were estimated by using the person-weighted

TABLE 4. Total Direct and Indirect, and Per Person Expenditures by Reporting Prevalence for All Illnesses and Skin Diseases for Persons Aged 16 to 65 Years in Seven Industry Sectors in the US Civilian Noninstitutionalized Population in 2004

	Illness Groups				
Expenditures and Prevalence	All Illness	Dehkharghani et al[13] Definition (SDD2)	All Diseases of the Skin and Subcutaneous Tissue (SDD)	Atopic, Contact, and Dermatitis Due to Drugs and Substances Taken Internally (DW)	Contact Dermatitis and Other Eczema (CDW)
Total direct and indirect expenditures ($millions)	$393,115.2	$13,411.5	$11,642.3	$1,220.2	$1,176.0
Direct expenditures ($millions)	$361,640.5	$9,654.4	$8,404.5	$582.1	$550.7
Indirect expenditures ($millions)	$31,474.6	$3,757.1	$3,237.8	$638.2	$625.2
Population illness prevalence (millions)	150.80	12.66	10.68	2.23	2.13
Per person expenditure prevalence ($)	$2,606.86	$1,059.36	$1,090.10	$547.17	$552.11

population values as the denominator (ie, the total costs row was divided by the total population row), whereas the prevalence for persons reporting an illness in MEPS was estimated by applying US weights on the number of persons reporting that illness in the sample.

Taking into account that the cost of SDD2 includes the cost of codes other than the codes included in SDD (Table 1), one can ascertain that the skin disease groups with codes other than the ICD-9-CM codes 680 to 709 (SDD) are contributing $1.8 billion to the total cost of SDD2, affecting ~2 million people. Comparisons of costs per person for each illness type and industry sector follow below.

Economic Burden

In Table 5, the total direct and indirect expenditures on all illnesses examined are reported for the sum of all industry sectors and for each sector separately. Note that MEPS and other national surveys use the criterion that sample size cells should contain ~100 observations to ensure that population weighting is valid. In fact, the all-illnesses group for six of the seven industry sectors examined and the all-services sector for each skin disease group examined were the only categories with reliable total, direct, and indirect cost estimates for the US population, determined from the aggregation of person weights. This is the result of the large number of reporting persons in those categories.

In Table 5, reliable total direct and indirect costs for the US population are reported for the all-illnesses group for all private industry (for the seven industry sectors examined) and each individual sector, every skin disease group for the all-services sector, the wholesale and retail trade sector for SDD and for SDD2, and the manufacturing sector for SDD2. In Table 4, the all-services sector accounts for approximately one half of the $1769.2 million difference between the cost of SDD and the cost of SDD2. This sector, containing several varied types of services,[28] had both the largest economic burden of the illnesses examined and the largest population reporting these illnesses. (This was true for every illness group in this sector.) According to BLS employment data presented in the last column of Table 5, all services also had the largest number of persons employed, followed by the wholesale and retail trade sector.

The last column of Table 5 includes the number of persons employed in the seven industry sectors examined, according to the BLS Quarterly Census of Employment and Wages.[30] For comparison purposes, one can contrast the number employed in the sectors (BLS data) to the number reporting illnesses (ie, the population prevalence) in the sectors (MEPS data). In every sector, the number of persons reporting all illnesses, not just skin disease, was far larger than the number employed in the sector. This may imply that more than one illness was reported per person in MEPS or may be a result of differences in sampling frameworks.

By Individuals

Table 6 presents another perspective on the estimates from this study. It provides the economic burden suffered per person, both by those reporting illnesses and by those employed in these sectors. Again, the reliability requirement of a minimum number of 100 observations per sample cell comes into play. Because of this limitation, the mining sector had unreliable estimates and was not included in Table 6. This resulted in new totals for the sum of all sectors.

In addition to the unreliable estimates for the mining sector, all other unreliable estimates were removed from Table 6. Two columns are presented for each illness group: 1) the cost per person calculated by using prevalence, Pr, (ie, the number of persons reporting illness in a sector) as the denominator and 2) the cost per person calculated by using the number of persons reported to be employed, NE, in a sector as the denominator. The economic burden was substantially higher for each skin disease group when it was calculated using Pr as the denominator. Nevertheless, this is not true for the cost of the sum of all sectors (less mining) and for the cost of each sector for the all-illnesses group. In each individual sector and in the sum of all sectors for the all-illnesses group, the NE cost per person was greater than the Pr cost per person. Individual sectors seemed to be more affected by the denominator selection for prevalence. Considering only those persons who were 16 to 65 years old, employed in the six sectors, and reported costs for SDD, the cost estimates for the all-services sector and the wholesale and retail trade sector using Pr were substantially higher that those derived by using NE. In general,

TABLE 5. Economic Burden of All Illnesses and Skin Diseases by Industry Sectors for Persons Aged 16 to 65 Years in Seven Industry Sectors in the US Civilian Noninstitutionalized Population in 2004, Including Population Estimates and the Number Employed in Each Sector

	Illness Groups With Population Estimates and Number Employed					
Industry Sectors	**All Illness**	**Dehkharghani et al13 Definition (SDD2)**	**All Diseases of the Skin and Subcutaneous Tissue (SDD)**	**Atopic, contact, and Dermatitis Due to Drugs and Substances Taken Internally (DW)**	**Contact Dermatitis and Other Eczema (CDW)**	**Number Employed From the BLS QCEW**
Totals by illness and by industry sectors	$393,115.2 (150.80)	$13,411.5 (12.66)	$11,642.3 (10.68)	$1,220.2 (2.23)	$1,176.0 (2.13)	107.6 (100.0
Agriculture forestry, and fishing	$2,792.8 (1.85)	$66.6* (0.09)	$14.8* (0.04)	$6.3* (0.01)	$6.3* (0.01)	1.0 (0.89)
Mining	$1,319.6* (0.71)	$9.9* (0.06)	$9.9* (0.06)	$1.7* (0.03)	$1.7* (0.03)	0.5 (0.48)
Construction	$24,714.7 (12.12)	$941.0* (0.62)	$575.1* (0.52)	$155.8* (0.15)	$155.8* (0.15)	6.9 (6.43)
Manufacturing	$41,674.2 (16.88)	$1,286.5 (1.29)	$976.3* (1.08)	$59.6* (0.14)	$52.8* (0.13)	14.3 (13.26)
Wholesale and retail trade	$5,133.7 (21.47)	$1,002.2 (1.53)	$939.1 (1.32)	$100.5* (0.29)	$96.6* (0.28)	20.7 (19.25)
Transportation, warehousing, and utilities	$25,780.4 (7.17)	$2,467.3* (0.37)	$2,365.0* (0.29)	$19.0* (0.05)	$19.0* (0.05)	4.6 (4.25)
All services	$245,496.1 (90.58)	$7,638.0 (8.70)	$6,762.1 (7.36)	$877.4 (1.55)	$843.8 (1.48)	59.6 (55.44)

Values are presented as $millions (population estimate).*Value is unreliable because sample data do not meet publication guidelines for MEPS. To be valid, the number of event observations should be *geq* 100.

one may conclude that this large difference in per person costs was due to fewer people being employed in the sector than were reporting being ill in the sector, as was shown in Table 5.

In addition, reliable cost estimates are demonstrated for SDD in the wholesale and retail trade sector and for SDD2 in the wholesale and retail trade sector and in the manufacturing sector. The cost of DW per person in all private industry (less mining), compared with that in the all-services sector, was ~$3 lower when using NE in the sector categories (Table 6). This difference in costs was slightly lower for CDW and much higher when comparing SDD ($4.85) and SDD2 ($3.02). The reverse was true when comparing both SDD versus SDD2 and DW versus CDW when using Pr as the denominator.

By Events

Table 7 presents the direct health care costs by type of health care event. The costs of each health care event experienced by each person were added across all events experienced by this person. The sum of all health care costs by all events is a measure of the US population's total health care costs.

The direct cost estimate for SDD was allocated to each event category as follows: 44.7% in ambulatory care, which is the sum of costs of health care provider office, emergency department, and outpatient visits; 33.2% in hospitalizations; 20.9% in prescription medications; and 1.1% in home health care visits. Ambulatory care costs were broken down further to 66.7% in health care provider office

TABLE 6. Per Person Economic Burden for All Illnesses and Skin Diseases by Reported Illness Prevalence (Pr) and by Number Employed (NE) in Industry Sectors (Excluding Mining) for Persons Aged 16 to 65 in Seven Industry Sectors in the US Civilian noninstitutionalized Population in 2004

	Illness Groups									
Industry Sectors	All Illness		Dehkharghani et al[13] Definition (SDD2)		All Diseases of the Skin and Subcutaneous Tissue (SDD)		Atopic, contact, and Dermatitis Due to Drugs and Substances Taken Internally (DW)		Contact Dermatitis and Other Eczema (CDW)	
	Pr	NE	Pr	NE	Pr	NE	Pr	NE	Pr	NE
All sectors less mining	$2,610.40	$3,658.22	$1,063.62	$125.13	$1,095.33	$108.61	$553.86	$11.38	$551.19	$10.96
Agriculture, forestry, and fishing	$1,509.62	$2,792.80	–	–	–	–	–	–	–	–
Construction	$2,039.17	$3,581.84	–	–	–	–	–	–	–	–
Manufacturing	$2,468.85	$2,914.27	$997.29	$89.97	–	–	–	–	–	–
Wholesale and retail trade	$239.11	$248.00	$655.03	$48.42	$711.44	$45.37	–	–	–	–
Transportation, warehousing, and utilities	$3,595.59	$5,604.43	–	–	–	–	–	–	–	–
All services	$2,710.27	$4,119.06	$877.93	$128.15	$918.76	$113.46	$556.06	$14.72	$570.14	$14.16

TABLE 7. ealth Care Event Expenditures for All Illnesses and Skin Diseases by Type of Event for Persons Aged 16 to 65 Years in Seven Industry Sectors in the US Civilian Noninstitutionalized Population in 2004

	Illness Groups				
Industry Sectors	All Illness	Dehkharghani et al13 Definition (SDD2)	All Diseases of the Skin and Subcutaneous Tissue (SDD)	Atopic, contact, and Dermatitis Due to Drugs and Substances Taken Internally (DW)	Contact Dermatitis and Other Eczema (CDW)
Total health care event expenditures	$361,640.5 (150.80)	$9,654.4 (19.59)	$8,404.5 (16.51)	$582.1 (3.62)	$550.7 (3.47)
Office-based medical provider visits	$220,082.5 (71.48)	$3,004.2 (9.05)	$2,508.1 (7.75)	$182.6 (1.50)	$173.5 (1.43)
Emergency room visits	$106,338.4 (17.49)	$500.6 (0.71)	$390.3 (0.52)	$61.4* (0.18)	$43.9* (0.12)
Outpatient visits	$2,302.7 (1.06)	$995.1 (0.62)	$863.9 (0.53)	$48.6* (0.04)	$48.6 (0.04)
Prescription medicines	$15,787.4 (13.63)	$1,957.8 (9.03)	$1,756.9 (7.55)	$188.3 (1.88)	$183.5 (1.85)
Hospital inpatient stays	$293.8 (0.05)	$3,105.6 (0.14)	$2,794.3* (0.13)	$101.2 (0.02)	$101.2 (0.02)
Home health visits	$7,670.7* (0.49)	$91.0 (0.03)	$91.0 (0.03)	–	–
All ambulatory care visits†	$328,723.6 (90.03)	$4,499.9 (10.38)	$3,762.3 (8.80)	$292.6 (1.72)	$266.0 (1.59)
All office-based visits and prescriptions	$235,869.9	$4,962.0	$4,265.0	$370.9	$357.0

Includes population estimates of persons reporting events. Values are presented as $millions (population estimate).
*Value is unreliable since sample data do not meet publication guidelines for MEPS. To be valid, the number of event observations should be *geq*100.
†Ambulatory is the sum of office-based, emergency room, and outpatient visits.

visits, 10.4% in emergency department visits, and 23% in outpatient hospital visits. Of these event categories, only health care provider office visits and prescription medications had reliable estimates for weighting to the US population. These event categories accounted for almost all health care costs because health care provider offices are the most frequently visited sites. Because emergency department visits and outpatient hospital visits were infrequent for each of these skin disease groups, the sum of costs of health care provider office visits and prescription medications dominated ambulatory costs. Ambulatory care costs for DW accounted for 11% of these costs for SDD in each of the seven industry sectors.

DISCUSSION

Brief Data Summary

The total economic burden was estimated to be $11.6 billion for SDD and $13.4 billion for SDD2. Direct costs were approximately three fourths of the total burden, ~$8.4 billion for SDD (2.3% of the cost of all illnesses) and $9.7 billion for SDD2 (0.2% of the cost of all illnesses). Lost productivity was estimated to be $3.2 billion for SDD (10% of the cost of all illnesses) and $0.6 billion each for DW and CDW (2% of the cost of all illnesses). Per person costs using Pr as denominator were higher for CDW than for DW. The opposite was true for NE. The implication of these estimates for per person costs is that policy makers should be mindful of the prevalence measures used for their analyses. For example, policy makers need to understand whether they are targeting prevention strategies to reduce the burden for all persons employed in a sector or only for those who report suffering a skin disease. The most common health care event was health care provider office visits. The economic burden of DW was estimated to be ~$1.2 billion, compared with $11.6 billion for all SDD; ie, the economic burden of DW was 10.5% that of SDD. Only all private industry and the all-services sector had reliable total, direct, and indirect cost estimates for the US population for all skin disease groups used in this study. Costs per employed person were $11.38 for DW in all private industry, $14.72 for DW in the all-services sector, $108.61 for SDD in all private industry, and $113.46 for SDD in the all-services sector.

CONSIDERATIONS

Illness and Work-Relatedness Identification

Many occupational illnesses manifest themselves as common medical problems, making it difficult to understand if they originated from work. Often exposure histories are not complete during health care provider office visits, and they also are not collected through surveys. As a result, an accurate diagnosis may not be made, the treatment offered may be inappropriate, and occupational exposure may continue without realization that it is the cause of the illness. The health care provider may not query the patient about his or her occupation; may have no training in occupational medicine and therefore be unfamiliar with symptoms of occupational disease; or may miss the cause of, or the exacerbating circumstances for, the illness. Information may not be gathered regarding the toxicity of the exposure and the duration of current and former occupations that could be crucial to the determination of a latency effect.

Although poor recognition and inappropriate treatment are common for many occupational diseases, dermatitis is especially challenging to accurately recognize and appropriately treat because it does not always manifest itself in a consistent manner. Mild acute cases are more frequent and may not require a visit to a health care provider's office or prescription medications; they are often self-treated with over-the-counter medications. Although some more severe cases require further care, many cases only last a few days. In addition, persons with chronic cases of dermatitis may experience related symptoms for weeks, months, and longer but may not associate them with work.

Medical Expenditure Panel Survey

For the purposes of this study, MEPS was used to provide information on health care expenditures for the US population who are in a specific age range, work in one of seven industry sectors, and have a specific skin disease requiring medical attention. Nevertheless, MEPS does not provide information that can be used to attribute specific illnesses to workplace exposures. In MEPS, data are classified on the basis of a description provided by the worker of health care services received. The health care problem is later reviewed by medical experts and classified into ICD-9 categories. MEPS data do not allow discerning when the condition was first diagnosed or manifested itself and how long it lasted but only if treatment was undertaken and what it cost. If no medical treatment was sought, if the illness was not recognized as skin disease, or if the person cannot recall its occurrence when being interviewed, the illness may not be reported and classified into the correct ICD-9-CM category of MEPS. Similarly, if the illness was not recognized and reported to the employer, it most likely would not be reported or included through other surveillance data collection efforts, including those by BLS.

Methodological Considerations

The COI method was used to estimate economic burden from the societal perspective. The economic burden was obtained by aggregating direct costs (ie, health care costs) and indirect costs (ie, productivity losses). COI estimates often exclude the value of time of those who do not work, such as children and retirees. This is not a limitation for the current study because these two age groups were excluded and the focus was on the working population. Nevertheless, a limitation specific to this study was that if working-age adults did not report an industry of employment, they were also excluded. Critics of the COI approach also point out that it does not include the value of pain and suffering or reductions in quality of life resulting from illness or injury. For lack of available data, these were excluded here. An additional controversial issue is whether individuals' wages accurately reflect the value of their full capacity when at work. For lack of data, wage information was used for this valuation. Finally, the wage value for caregivers who do not typically work outside the home, also excluded in this study, is controversial. Often, imputations are suggested to address this issue. For example, the value of lost household work might be imputed using wage data of workers providing similar services as cleaners, cooks, babysitters, nurses, or maids.

Some Evidence

Economic estimates of the burden of dermatitis are limited, and estimates of any type of occupational skin disease are scarce. As mentioned previously, some estimates exist of the numbers of cases of skin disease but not costs, and few studies have been undertaken for recent time periods. Existing studies exploited more than one survey to determine costs, and skin illness groups were defined differently in each study. For example, a study by Ellis et al[14] and a study by Fowler et al[15] both focused on more specific skin disease groups and used employee claims from an administrative database to estimate employer or insurer burden. Dehkharghani et al[12] reported on costs for 1997 of a broad category of skin disease, and a similar study by Bickers et al[13] reported results for 2004.

Ellis et al[14] reported on other AD and related conditions, which includes eczema[27]—a noncontagious skin disease characterized by chronic inflammation of the skin when a hereditary predisposition toward developing hay fever and other allergic reactions exists. These skin conditions may be associated with occupations that require frequent hand washing, such as medical professionals, daycare workers, and hairdressers. Ellis et al[14] estimated the costs of health care services and prescription medications from 1997 to 1998

using data from a private-managed care provider and a state Medicaid program. Direct cost estimates included patient costs borne by the insurer-payer. Indirect costs were not estimated. Direct costs were estimated to be $0.9 billion to $3.8 billion when projected across the total number of persons younger than 65 years who were insured by private insurers and Medicaid in the United States. This estimate was compared with $1.2 billion for the larger category containing AD, CD, and dermatitis due to drugs or substances taken internally in 2004. Similar to Ellis et al,[14] a study done by Fowler et al[15] estimated the incremental or additional costs to employers for employees in this more restrictive illness category. They used a database of administrative claims from 31 self-insured employers over an 8-year period to estimate costs of employee medical claims paid by employer-payers. Indirect costs included work-loss costs such as disability and sick leave. They reported $60.5 billion for AD alone compared with our $44 million for AD plus dermatitis due to drugs and substances taken internally combined, or DW less CDW. The study by Ellis et al included other dermatitis including eczema (691.8), contact dermatitis (692), and noninfectious dermatoses of the eyelids (373.3) and the study by Fowler et al used reported AD and related conditions (691.0) plus other dermatitis including eczema (691.8) or 691.8 alone.

The skin-disease group used by Dehkharghani et al[12] included illnesses such as skin infections, cancers, viruses, and warts. We used SDD2 to mimic their definition of illness. Direct costs accounted for over-the-counter medications, including items such as skin and hand lotions, deodorants, feminine hygiene products, and baby care products. The authors used more than one survey by the National Center for Health Statistics of the Center for Disease Control and Prevention, each created with different purposes, and one obtained from a pharmaceutical marketing research organization. In addition, numerous assumptions were made for adjusting data such as applying proportions from total health care information to skin-specific conditions. The estimate of Dehkharghani et al[12] for the 1997 economic burden for all, not just occupational, skin disease for the entire population was $35.9 billion, more than three times the cost of SDD2 in this report.

Bickers et al[13] also estimated costs. They claimed that their approach was an improvement over Dehkharghani et al[12] because they broadened the skin disease definition to include 22 ICD-9-CM categories, including skin cancer mortality, and they included a quality-of-life estimate in their productivity loss calculations. They combined data from many different sources and years and adjusted for inflation. Note that this is the only existing study that considered fatalities in the estimation of skin disease burden. Bickers et al estimated the cost of CD at $1.6 billion and the cost of AD and CD combined at $2.6 billion. They used the entire US population, not just working-age adults, and included an estimate for over-the-counter medications. Therefore, the current report's estimates of $550.7 million for CDW and $582 million for DW seem reasonable.

Previous studies mentioned that used populations with health insurance might have overestimated the use of medical care and the number of illnesses experienced by these populations. None of the previous studies we mentioned focused on all occupational skin diseases or attempted to estimate costs by industry sectors, using a societal perspective. Each of these previous studies used different methodologies than the one used in this report and obtained data from a number of different sources. Using data from different sources can be problematic because survey data may be collected for different purposes and may use different sampling techniques, which might adversely affect the quality of the data analyses.

The number of workers suffering from occupational skin disease has been decreasing. The incidence of occupational dermatitis, a subcategory of occupational skin disease, has dropped dramatically since estimates of Burnett et al[3] that used 1993 BLS data. For that year, BLS reported 8835 cases of occupational dermatitis with DAFW, or 1.12 cases per 10,000 workers. In 2004, BLS reported incidence at only 3220 cases for occupational dermatitis with an incidence rate of 0.4 cases per 10,000 workers, a drop of ~60% from 1993. During the same year, the incidence of occupational skin disease constituted 15.6% of all occupational illnesses reported by the BLS through the annual Survey of Occupational Illnesses and Injuries.[1] BLS reported a new case rate for occupational skin disease of 4.4 per 10,000 workers, or 38,900 new cases, in the US workforce in 2004. This represented a sizeable decrease from a reported incidence of 6.7 per 10,000 workers, or 57,900 new cases, in 1997.[31] In 2004, when DAFW are considered, the incidence for occupational skin disease was 0.5 per 10,000 workers, or 4800 reported new cases, and the incidence for occupational dermatitis was 0.4 per 10, 000 workers, or 3220 reported new cases. Because of limitations of the Survey of Occupational Illnesses and Injuries, the aforementioned estimates are often considered to be substantially underreported.

In 1988, a special supplemental survey conducted as part of the National Health Interview Survey collected specific data on occupational CD. The rate of new cases, defined as occupational CD occurring in the previous year, was 1.7% in 1988.[32] When projected to the employed civilian labor force aged 16 years and older, this rate represented 1.87 million persons. Applying this same rate to 2004, 2.37 million persons would have been expected to suffer from occupational skin disease, which seems unrealistic given the reduction in incidence over the past decade, as reported by the BLS. The incidence of ill workers with DAFW also declined since 1988, so that one might surmise that prevalence in 1 year, 2004, may also be lower, as reported in this study. Because estimates in this study are for a smaller population group and limited to those working in specific industry, they would necessarily be smaller than these earlier studies.

Mortality

None of the cost studies discussed earlier used fatalities, except the study by Bickers et al[13] that used cancer mortality. MEPS does not include information on fatalities. Fatalities, for many illnesses, are often preceded by considerable medical treatment and would have a direct effect on future health care costs. Fatalities also significantly affect indirect costs through productivity losses. Measuring the time and the value of output lost from the age at death to the age that the individual's productive life would normally end can result in exceptionally large values if an individual died at a young age and early in their career or if a large group died at one time. If fatality information was included in this report, productivity loss estimates would have increased, probably outweighing direct costs.

Severity

Two studies emphasized severity. Fivenson et al[33] analyzed a managed care plan in Detroit for 1997. Costs varied significantly based on the severity of AD and included only other AD and the related condition eczema (ICD-9-CM code 691.8). Severity was defined by self-report and in some cases by chart reviews, using either the intensity of itching or the extent of the illness. Barbeau et al[16] found that costs were four times greater for those with severe AD relative to mild cases. Severity was defined as the amount of itching and if the itching disturbed one's sleep. Neither study was done to estimate a societal perspective by industry sectors. Our study found AD to be a very small amount of occupational illness costs.

No surveys exist that provide information on acute and chronic cases of occupational skin disease or the course and length of the disease. Although MEPS contains the commercial names of prescription medications and the number of refills, which may be used to examine severity, information on dosage and usage length is not available. For acute and chronic severity, one might consider accounting for the amount of inactivity or for workdays lost by illness severity for the type of reaction (ie, immediate or delayed), for short-term and long-term types of medical care, and for the perceptions an individual has regarding their health status or quality of life.

Surveillance

Surveillance for occupational dermatitis is limited by factors such as underreporting; the poor understanding of the process of transmission, absorption, and reaction in the human population; and the difficulties related to the identification of pathogens or agents that cause occupation dermatitis. Understanding is incomplete for the discrepancy between actual cases and reported cases and for the accurate level of severity in reported cases. Perhaps a combination of active and passive reporting would improve the quality of surveillance data.

As mentioned, no single source of data is available to provide all the necessary information for assessing the true burden of occupational skin disease. Each existing source has limitations resulting in the need for many assumptions. The ideal would be a survey specifically asking questions on skin disease, the expenses involved by individual employees and employers, and whether the illness is clearly work related.

CONCLUSIONS

Occupational skin disease is a significant burden for employees, employers, and ultimately society, but calculating its societal cost is challenging because of the poor quality of available data. MEPS data on health care expenditures and demographic information from a national representative sample of members of US households were successfully used in this study to estimate the burden of skin disease in working adults. Although MEPS provides information on persons who work in an industry or occupation and have a specific illness that requires medical attention, it does not provide information on whether these persons became ill from a work-related exposure. In addition, MEPS does not provide information on whether a specific condition was first diagnosed or manifested during the time period examined; therefore, no consideration can be given to when the condition occurred but only that treatment was undertaken. As mentioned earlier, currently available data probably provide an undercount of skin disease in working adults in general and DW, specifically because many cases of both conditions often are self-diagnosed and self-medicated. In addition, currently available data do not provide information on the type and length of the exposures that cause DW or on the duration of DW. These limitations are due to the lack of appropriate surveillance data, not due to the lack of appropriate economic evaluation methods. Despite these limitations, this study provides the first known estimate of DW by industry sectors and is a starting point in the continued investigation of the true economic burden of DW and its relationship to the overall burden of SDD. Advances in technology that include improved identification of how skin tissues react to chemical exposures are expected to facilitate the development of an improved surveillance system for occupational skin disease and occupational dermatitis. Improved surveillance, including recognition of hazards, exposure identification, and accurate reporting of the work relatedness of exposures and cases, would increase our understanding of the epidemiologic and, as a consequence, the economic burden of DW and SDD, leading to improved opportunities for prevention.

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