Work-related amputations by type and prevalence

Based on workers' compensation cases, new supplement to annual BLS survey of occupational injuries yields a 1977 estimate of 21,000 cases, most involving the loss of a finger

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Each year, American workers suffer disfiguring and often seriously disabling amputations as a result of their jobs. This study estimates that 21,000 such accidents took place in 1977, and attempts to isolate the industries, occupations, and situations in which they were most likely to occur. Also included is a brief discussion of the medical and income maintenance costs incurred by State workers' compensation systems in settling claims of injured workers.

The data. This analysis is based on 1977 data from the Supplementary Data System (SDS), which augments the Bureau of Labor Statistics' annual survey of occupational injuries and illnesses.[1] Each of the cases selected for study represents an individual who suffered a work-related "amputation" or "enucleation" (such as loss of an eye); both of these types of injuries will be referred to as "amputations" in subsequent discussion.

Two categories of cases are reported by participating State workers' compensation agencies in the SDS: "closed" and "current." A "closed" case is one for which a worker had received all compensation and medical payments due for the injury by the end of the reference year, regardless of the year in which the case occurred or was reported.[2] A "current" case, on the other hand, either occurred or was reported during the reference year, depending upon the State. For 1977, most States submitted current case data, a few only closed cases, and three States submitted both.

The minimum number of lost workdays required before a case is reported varies by State. Some include all reported cases, and other States include cases with 1 or more lost workdays, 4 or more lost workdays, and so forth. Consequently, interstate comparisons of SDS data must be made very cautiously, and combinations of State data used in this article should not be taken as a census or reliable sample of a universe of similar cases. Data are combined here, however, because the distributions of cases among States do not vary greatly.

Number of amputations. There is no national survey of the specific nature of occupational injuries (that is, the number or frequency of amputations, sprains, fractures, and so forth.[3] However, by making certain assumptions, we can make a reasonable estimate of a national total of about 21,000 amputations in 1977. This procedure combines the "current case" SDS information and non-injury-specific data from the Bureau's annual survey of occupational injuries and illnesses.[4]

The estimate of the national total of amputations in 1977 (A_t) is obtained by summing the number of "current case" amputations reported by 22 States for 1977 (A_n),[5] dividing by the sum of lost workday cases reported for these States in the 1977 annual survey of occupa-

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tional injuries and illnesses (LWC_n), and multiplying by the total number of lost workday cases for the country that year (LWC_t):

$$\left(\frac{(A_1 + A_2 \ldots\ldots A_{22})}{(LWC_1 + LWC_2 \ldots\ldots LWC_{22})}\right)(LWC_t) = A_t$$

Thus,

$$\left(\frac{8{,}381}{866{,}623}\right) 2{,}203{,}600 = 21{,}311$$

for an estimate of about 21,000 amputations nationally.

The assumptions required to justify this computation are that (1) all amputations entered in the SDS are reported as lost workday cases in the annual survey; (2) the total industrial and labor force compositions of the participating SDS States are representative of those of nonparticipating States; and (3) the long minimum lost workday periods before a case is submitted to the SDS by some States will not screen out a significant number of amputations. The last of the foregoing assumptions is the weakest. Some amputations, particularly those affecting the first (distal) joint of a finger, may not result in more than 2 or 3 lost workdays. These would not be reported by a State submitting only cases involving 4 or more lost workdays. For 1977, Colorado, Maryland, and Wisconsin submitted cases involving 4 or more lost workdays, Michigan reported cases involving 7 days or more, and New Mexico and Tennessee submitted those resulting in at least 8 lost workdays. Consequently, the national estimate probably understates the number of "minor" amputations. However, because so few States use the longer minimum periods, the understatement does not make the estimate implausible and, in the absence of comparable information, certainly does not make it valueless.

Amputations by industry. Table 1 presents the distribution of amputations by industry division, and for selected 3-digit SIC coded industries. Manufacturing accounted for about 30 percent of employment, but almost 60 percent of the amputations. The 3-digit manufacturing industries listed had 6.3 percent of the employment, but 18.6 percent of the amputations. These are the industries one associates with such injuries; they have many cutting, sawing, and stamping activities. Agriculture, forestry, and fisheries, mining, and construction also had relatively high proportions of amputations.

Method for examining cross-tabulations. Tables 2, 4, 5 and 6 show the number of cases and adjusted standardized residuals (ASR's) for the source of injury by industry, by part of body affected, by type of accident, and for occupation by part of body affected. The ASR's are indicators of the table cells which have greater than expected numbers of amputations. The method by which they are calculated is presented in the appendix to this article.

Table 1. Percent distribution of work-related amputations and employment by industry division and selected industries, private sector, 23 States, 1977

Industry divisions and selected industries	Employment [1]	Amputations [2]
Agriculture, forestry, and fisheries	.6	2.7
Mining	.9	2.9
Construction	5.3	9.0
Manufacturing	30.7	59.8
Meat products	.5	1.9
Sawmills and planing mills	.6	2.3
Millwork, plywood, and structural members	.8	2.2
Miscellaneous plastics products	.7	1.8
Fabricated structural metal products	.6	2.2
Metal forgings and stampings	.5	2.3
Miscellaneous fabricated metal products	.4	1.6
Motor vehicles and equipment	2.2	4.3
Transportation and public utilities	6.1	3.1
Trucking, local and long distance	1.7	1.9
Wholesale and retail trade	28.2	15.8
Grocery stores	2.5	2.9
Eating and drinking places	6.2	2.7
Finance, insurance, and real estate	6.8	.7
Services	21.5	5.8
Unidentified	—	.1

[1] Employment data were obtained from *County Business Patterns, 1977* (Bureau of the Census, 1979). Employment data for Maine were obtained from *County Business Patterns 1976* (Bureau of the Census, 1978).

[2] Injury data are from 1977 SDS records of 8,602 "current-case" amputations. States included are Alaska, California, Colorado, Connecticut, Hawaii, Idaho, Indiana, Iowa, Kentucky, Maine, Maryland, Michigan, Missouri, Montana, Nebraska, New Jersey, New Mexico, Oregon, South Dakota, Tennessee, Utah, Vermont, and Wisconsin.

NOTE: Due to rounding, sums of industry division percentages may not equal 100.

The advantage of the adjusted standardized residuals is that, when the variables in the table are independent, the ASR's are approximately normally distributed with mean equal to zero and standard deviation equal to 1.[6] Thus, there is only a 5-percent chance of an ASR value greater than 1.96 or less than −1.96 occurring if the observed frequency in a cell is only a random variation from the expected value. If the value is greater than 1.96 or less than −1.96, we can assume that the number of cases in the cell is significantly different from the expected value, and that there is an unusually strong relationship between the two cross-classified variables.

Source of injury by industry. Table 2 presents the cross-classification of industry by source of injury. "Machines" were the leading cause of injury in every division except mining and transportation and public utilities, and were nearly as important as "metal items" in mining. The adjusted standardized residuals indicate that the machines category was heavily overrepresented in manufacturing. Consequently, fewer such cases than expected appear in other industries, although the *absolute* numbers are still quite high. Table 3, which shows the source-of-injury distribution in more detail, indicates that a small group of machines accounted for 2,752 of the 4,645 machine accidents.

Other notable sources of injury in specific industries were "metal items" and "hoisting apparatus" in mining

Table 2. Source of injury by industry: numbers of cases and adjusted standardized residuals,[1] 1977

Industry	Boxes, containers	Buildings, structures	Conveyors	Electrical apparatus	Hand tools, nonpowered	Hand tools, powered	Hoisting apparatus	Machines	Mechanical power transmission apparatus	Metal items	Vehicles	Miscellaneous or unknown	Total cases
Total cases	198	119	199	63	314	446	174	4,645	359	996	509	580	8,602
Agriculture, forestry, and fisheries	2 (1.49)	5 (1.01)	10 (2.04)	4 (1.79)	13 (1.59)	16 (1.17)	5 (.14)	95 (-4.11)	23 (4.41)	18 (-1.86)	23 (2.59)	19 (.87)	233
Mining	2 (-1.61)	1 (-1.35)	13 (3.08)	4 (1.63)	18 (3.04)	7 (-1.73)	32 (12.28)	56 (-10.17)	19 (2.75)	57 (5.63)	11 (-1.03)	30 (3.36)	250
Construction	23 (1.32)	9 (-.54)	15 (-.71)	8 (1.04)	37 (1.78)	164 (21.11)	24 (2.25)	242 (-13.20)	19 (-2.49)	120 (3.62)	39 (-1.06)	71 (2.86)	771
Manufacturing	113 (-.81)	41 (-5.69)	134 (2.18)	29 (-2.25)	110 (-9.14)	164 (-10.21)	68 (-5.65)	3,269 (21.59)	207 (-.86)	572 (-1.65)	184 (-11.24)	257 (-7.90)	5,148
Transportation and public utilities	23 (6.97)	8 (2.28)	5 (-.50)	5 (2.21)	4 (-1.91)	4 (-2.77)	6 (.26)	35 (-13.66)	21 (3.05)	43 (2.32)	82 (17.40)	32 (3.45)	268
Wholesale and retail trade	26 (-1.06)	34 (3.83)	16 (-3.05)	12 (.70)	95 (7.12)	50 (-2.75)	26 (-.33)	697 (-2.31)	36 (-3.08)	142 (-1.46)	111 (3.80)	118 (3.07)	1,363
Finance, insurance, and real estate	1 (-.29)	4 (3.61)	0 (-1.18)	0 (-.66)	2 (-.08)	8 (2.97)	1 (-.16)	21 (-2.73)	5 (1.70)	7 (.12)	3 (-.24)	6 (1.10)	58
Service	7 (-1.40)	17 (3.95)	6 (-1.72)	1 (-1.45)	35 (4.08)	33 (1.43)	11 (.27)	227 (-4.11)	28 (1.61)	36 (-3.19)	55 (4.91)	47 (2.40)	503
Unidentified	1 (1.92)	0 (-.34)	0 (-.44)	0 (-.24)	0 (-.55)	0 (-.66)	1 (2.11)	3 (-.94)	1 (1.18)	1 (-.08)	1 (.79)	0 (-.76)	8

[1] Adjusted standardized residual explained in text. It is the second of the two figures shown for each combination of variables.

NOTE: Data are based on reports of current cases for 23 States.

and construction; "powered hand tools" in construction; and "vehicles" in transportation and public utilities, wholesale and retail trade, and services.

Source of injury by part of body affected. According to data presented in table 4, 91 percent of the amputations were of the finger(s), and 3 percent were of the toe(s). Most finger amputations (56 percent) involved machines. Toe amputations frequently involved metal items, vehicles, and—absolutely, if not according to the adjusted standardized residual—machines.

In addition to machines, conveyors and metal items were a substantial cause of arm amputations. Conveyors, vehicles, and boxes and containers were frequent sources of leg amputations. Vehicles, besides being the largest identified cause of leg amputations, produced many amputations at the ankle and toe(s).

Using 1977 data from three "closed-case" States (Arkansas, Idaho, and North Carolina), the following tabulation indicates the differences in compensation and medical costs for amputations of different parts of the body. Finger and toe amputations together accounted for 96.8 percent of the cases in these States, and 83.5 percent of the costs. Amputations and enucleations involving major extremities and the eyes were 2.7 percent of the cases but 14.8 percent of the costs. (The relative costs of amputations of different parts of the body are discussed in detail in a later section.)

Part of body	*Percent of—* Cases	Cost
Eye	.2	.7
Arm	.8	5.4
Hand, wrist	1.4	7.2
Finger(s)	94.6	81.0
Leg	.2	.9
Ankle	.1	.6
Toe	2.2	2.5
Other or unclassified	.5	1.6
Total	100.0	100.0

Source of injury by type of accident. Table 5 shows that the overwhelming majority of amputations involved workers being caught in, under, or between objects (65.9 percent), striking against objects (15.9 percent), and being struck by objects (15.0 percent). Workers being caught in, under, or between machines, or striking against parts of machines accounted for 4,358, or almost 51 percent, of the cases; the adjusted standardized residuals for the two cells (13.36 and 15.69, respectively) also indicate that machine cases were concentrated in these particular accident types. Other significant combinations were those involving workers being struck by metal items and being caught in mechanical power transmission apparatus and conveyors.

Occupation by part of body affected. Among the major occupational categories listed in table 6, "operatives, except transportation" incurred the largest number of amputations—2,918, or 34 percent of the cases. Certain specific occupations within this general category had particularly large numbers of such accidents. Assemblers (209 cases), meat cutters and butchers (128 cases), precision machine (such as drill press, grinder, lathe, or milling machine) operators (193 cases), punch and stamping press operatives (253 cases), and sawyers (171 cases) accounted for 954 of the category's 2,918 amputations. Not surprisingly, because they work closely with machines and tools, these operatives suffered both absolutely and relatively high numbers of finger amputations.

The second highest incidence of injury was among "craft and kindred workers;" 1,709 accidents—about 20 percent of the total—were reported for the category as a whole. Within this group, mechanics and repairers had 557 cases, with heavy equipment mechanics accounting for 195. Carpenters also had 262 cases. Although large, the number of finger amputations for craftworkers was proportionate to that for all workers.

"Laborers, except farm" were the third largest group (1,340 cases or about 15 percent) with especially numerous amputations of the toe and leg and at the ankle.

Table 3. Distribution of work-related amputations by selected sources of injury, private sector, 23 States, 1977

Source	Number of current cases	Percent of total
Total	8,602	100.0
Boxes, containers	198	2.3
Reels, roles	55	.6
Containers, n.e.c.	54	.6
Buildings, structures	119	1.4
Doors, gates	92	1.1
Conveyors	199	2.3
Powered conveyors	163	1.9
Electrical apparatus	63	.7
Motors	25	.3
Hand tools, nonpowered	314	3.7
Knives	120	1.4
Ropes, chains	38	.4
Hand tools, powered	446	5.2
Saws	290	3.4
Hand tools, powered, n.e.c.	64	.7
Hoisting apparatus	174	2.0
Cranes, derricks	55	.6
Jacks	27	.3
Machines	4,645	54.0
Buffers, grinders, and similar machines	191	2.2
Drilling, boring machines	196	2.3
Planers, shapers, molders	231	2.7
Presses (not printing)	796	9.3
Saws	711	8.3
Shears, slitters, slicers	627	7.3
Machines, n.e.c.	1,073	12.5
Mechanical transmission apparatus	359	4.2
Chains, ropes, cables	114	1.3
Metal items	996	11.6
Auto parts	74	.9
Metal items, n.e.c.	700	8.1
Vehicles	509	5.9
Highway vehicles, powered	204	2.4
Forklifts, and similar vehicles	151	1.8
Miscellaneous or unknown	580	6.7

n.e.c. = not elsewhere classified.

Farm laborers showed the same pattern, although for a much smaller number of cases. Transportation equipment operatives accounted for 282 cases (199 involving truck drivers), with relatively large numbers of amputations of the hand or wrist, toe, and leg.

The following tabulation shows that, in 1977, costs for three "closed-case" States (Arkansas, Idaho, and North Carolina) were distributed across these occupational categories in about the same way as the percentage of cases.

Occupational category	*Percent of—* Cases	Cost
Total	100.0	100.0
Professional and technical personnel	.6	.4
Managers	1.7	1.9
Salesworkers	.3	.1
Clerical personnel	1.0	.6
Craft and kindred workers	26.1	28.1
Operatives, except transportation	45.8	45.8
Transportation equipment operatives	2.8	2.7
Laborers, except farm	17.9	17.8
Farm laborers	1.1	.8
Service workers	1.8	1.1
Unidentified	1.0	.6

More about costs. Data on work-loss compensation and medical costs are available for some States which provide "closed-case" information. Such costs are, of course, only a part of the total economic and social price of work-related amputations. However, they are the most easily measured component of that price, and may give an indication of the overall relative severity of different types of injuries.

The final compensable cost of an amputation to the State is influenced by a variety of factors; the part of the body involved, the time lost from work, the duration of payments, the level of benefits provided by the State, and occupational and personal characteristics of the worker all enter into the eventual amount paid. This means that single or bivariate (cell-type) tabulations of cost data have certain limitations. While we can assess the average costs of particular types of amputations without knowing the years in which the cases occurred, or the wages and ages of the injured workers, it would be useful to estimate the cost of particular types of amputations if all other factors were constant.

The SDS obtains only some of the relevant information. However, for three "closed-case" States (Arkansas, Idaho, and North Carolina) in 1977 there were, among other items, data on total compensation and medical costs, the year in which the amputation occurred, the part of the body affected, the extent of disability, and the wages and age of the injured worker.

Accordingly, these data were subjected to an analysis of variance in total cost due to year of occurrence, part of body affected, extent of disability, and the weekly wage and age of the worker. The part of body affected

Table 4. Source of injury by part of body affected: numbers of cases and adjusted standardized residuals,[1] 1977

Part of body	Boxes, containers	Buildings, structures	Conveyors	Electrical apparatus	Hand tools, nonpowered	Hand tools, powered	Hoisting apparatus	Machines	Mechanical power transmission apparatus	Metal items	Vehicles	Miscellaneous or unknown	Total cases
Total cases	198	119	199	63	314	446	174	4,645	359	996	509	580	8,602
Eye	0 (−.59)	0 (−.46)	0 (−.60)	0 (−.33)	1 (.62)	0 (−.91)	1 (1.28)	1 (−3.68)	0 (−.81)	5 (2.64)	0 (−.97)	7 (6.17)	15
Arm	2 (−.10)	1 (−.26)	10 (5.44)	2 (1.61)	0 (−1.89)	1 (−1.80)	2 (.09)	41 (−1.93)	5 (.58)	11 (.08)	3 (−1.11)	15 (3.63)	93
Hand, wrist	4 (.41)	1 (−.70)	3 (−.16)	0 (−1.03)	5 (−.08)	6 (−.52)	1 (−1.13)	88 (1.92)	7 (.45)	9 (−1.97)	10 (.57)	8 (−.53)	142
Finger	171 (−2.32)	110 (.54)	160 (−5.30)	58 (.29)	300 (2.85)	416 (1.71)	154 (−1.17)	4,411 (13.84)	340 (2.49)	866 (−4.79)	406 (−9.16)	438 (−13.53)	7,830
Leg	6 (2.17)	4 (2.00)	9 (4.05)	0 (−.92)	0 (−2.07)	1 (−2.06)	2 (−.18)	20 (−7.72)	3 (−.80)	10 (−.88)	23 (6.60)	34 (10.03)	112
Ankle	3 (1.91)	0 (−.81)	3 (1.90)	0 (−.58)	0 (−1.32)	0 (−1.59)	3 (2.17)	5 (−5.88)	0 (−1.42)	13 (3.55)	11 (5.19)	8 (2.89)	46
Toe	10 (1.79)	3 (.27)	11 (2.20)	1 (−.63)	4 (−1.77)	21 (2.29)	10 (2.23)	51 (−10.91)	3 (−2.40)	74 (8.96)	34 (5.17)	30 (3.32)	252
Other[2] or unknown	2 (−.37)	0 (−1.26)	3 (.26)	2 (1.32)	4 (−.04)	1 (−2.06)	1 (−.86)	28 (−6.20)	1 (−1.75)	8 (−1.48)	22 (6.20)	40 (12.31)	112

[1] Adjusted standardized residual explained in text. It is the second of the two figures shown for each combination of variables.

[2] May include some cases involving previous categories which were not coded at sufficient detail to be specifically identified.

NOTE: Data are based on reports of current cases for 23 States.

was clearly the largest determinant of case cost; that factor had the highest F-value in each of the States. The eventual cost of an amputation was also substantially determined by its year of occurrence.

Virtually all of the amputations were classified into two extent-of-disability codes—temporary disability and permanent partial disability. Except in Idaho, the extent of disability variable was not a strong explanatory factor for the variance in cost. Similarly, neither the workers' wages nor ages affected differences in case costs once one controlled for the preceding factors, except for the effect of wages in North Carolina which,

Table 5. Source of injury by type of accident: numbers of cases and adjusted standardized residuals,[1] 1977

Type of accident	Boxes, containers	Buildings, structures	Conveyors	Electrical apparatus	Hand tools, nonpowered	Hand tools, powered	Hoisting apparatus	Machines	Mechanical power transmission apparatus	Metal items	Vehicles	Miscellaneous or unknown	Total cases
Total cases	198	119	199	63	314	446	174	4,645	359	996	509	580	8,602
Struck against	21 (−2.06)	5 (−3.51)	3 (−5.62)	9 (−.35)	36 (−2.19)	141 (9.32)	3 (−5.17)	1,004 (15.69)	5 (−7.68)	68 (−8.33)	24 (−7.12)	49 (−5.08)	1,368
Struck by	47 (3.48)	8 (−2.55)	6 (−4.79)	6 (−1.22)	173 (20.26)	164 (13.22)	36 (2.12)	250 (−27.08)	9 (−6.77)	350 (18.92)	87 (1.36)	155 (8.18)	1,291
Fall from elevation	0 (−.91)	1 (.75)	0 (−.91)	0 (−.51)	0 (−1.15)	0 (−1.39)	1 (.35)	2 (−5.74)	0 (−1.24)	1 (−1.62)	4 (1.38)	26 (15.97)	35
Fall same level	1 (−.10)	1 (.42)	0 (−1.07)	0 (−.60)	0 (−1.35)	0 (−1.62)	0 (−1.00)	8 (−5.20)	0 (−1.45)	2 (−1.61)	2 (−.52)	34 (17.76)	48
Caught in, under, or between	126 (−.68)	104 (4.98)	190 (8.90)	43 (.40)	86 (−14.67)	126 (−17.23)	134 (3.12)	3,354 (13.36)	344 (12.22)	558 (−6.99)	357 (2.08)	247 (−12.27)	5,669
Rubbed, abraded	1 (.01)	0 (−.78)	0 (−1.01)	0 (−.56)	15 (10.95)	11 (6.05)	0 (−.94)	6 (−5.28)	0 (−1.37)	6 (.49)	0 (−1.65)	4 (.67)	43
Motor vehicle accident	0 (−.86)	0 (−.66)	0 (−.86)	0 (−.48)	0 (−1.09)	0 (−1.30)	0 (−.80)	(−5.68)	0 (−1.16)	0 (−2.02)	30 (21.48)	0 (−1.50)	31
Miscellaneous	2 (−.43)	0 (−1.29)	0 (−1.68)	5 (4.52)	4 (−.13)	4 (−.87)	0 (−1.56)	20 (−8.06)	1 (−1.81)	11 (−.74)	5 (−.76)	65 (21.20)	117

[1] Adjusted standardized residual explained in text. It is the second of the two figures shown for each combination of variables.

NOTE: Data are based on reports of current cases for 23 States.

according to the zero-order correlation coefficient, was small but significant.

A "multiple classification analysis" of the effects of selected categorical factors (year of occurrence, part of body affected, and extent of disability) on final cost was also conducted. This procedure involves adjusting the average cost for a given category as it originally appears in the data by controlling for the effects of all other variables. For example, the average unadjusted cost for a case occurring in Arkansas in 1976 was $3,480. Some of the dollar difference between this and the averages for other years is due to the fact that cases in 1976 involved a unique distribution of parts of body affected, types of disabilities, and workers with different wages and of different ages. By controlling for the effects of these other factors, we can obtain an estimate of the average *adjusted* cost of a case which occurred in 1976 which is not affected by such inter-year variations. If we eliminate the influences of the unique combination of factors in 1976, the average adjusted cost of an Arkansas case which occurred that year and was closed in 1977 becomes $3,535.

Results of the multiple classification analysis show that, generally, the earlier a case occurred, the higher the total cost by 1977. (The 1977 cases in Idaho and 1973 cases in North Carolina are exceptions.) While the older cases could have been more serious, resulting in longer payment periods and larger totals, the more severe recent cases may not have been closed by 1977. When other factors were controlled, amputations of the arm and wrist were generally found to be the most costly. Toe and finger amputations, while numerous, were the least expensive. And, temporary disabilities, which presumably involve amputations with no lasting loss of working effectiveness, were relatively infrequent and much less expensive than permanent partial disabilities.

Generally, then, the part of body affected is the most significant influence on cost in each State. However, even for amputations involving the same parts of body, the years in which the cases occurred and the extents of disability also strongly affect how much cases eventually cost by 1977. These several factors should be considered when interpreting the relative costs of amputations based on "closed-case" workers' compensation data, and indicate that single or bivariate tabulations of such data should be used cautiously.

Detailed results of the analysis of variance and the multiple classification analysis, upon which the preceding general observations are based, are available from the author upon request.

THE NEW Supplementary Data System can suggest investigation of injury causation in unprecedented detail. But the system itself is still in the developmental stages, and many gaps and inconsistencies in reporting procedures among the participant States remain. As the system is expanded and refined, further analyses such as the one presented in this article may help policymakers, employers, and workers to determine and minimize those specific combinations of circumstances most likely to result in amputations and other job-related injuries.

Table 6. Part of body affected by occupation: numbers of cases and adjusted standardized residuals,[1] 1977

Part of body	Professional and technical	Managerial, except farm	Sales	Clerical	Craft and kindred workers	Operatives, except transportation	Transportation equipment operators	Laborers, except farm	Farmers	Farm laborers	Service	Miscellaneous or unknown	Total cases
Total cases	67	200	35	89	1,709	2,918	282	1,340	3	138	391	1,430	8,602
Eye	0 (−.34)	1 (1.12)	0 (−.25)	0 (−.40)	5 (1.31)	2 (−1.69)	0 (−.71)	5 (1.90)	0 (−.07)	0 (−.49)	2 (1.64)	0 (−1.73)	15
Arm	1 (.33)	3 (.58)	1 (1.02)	0 (−.99)	12 (−1.69)	30 (−.34)	3 (−.03)	14 (−.14)	0 (−.18)	1 (−.41)	7 (1.39)	21 (1.55)	93
Hand, wrist	1 (−.10)	1 (−1.29)	0 (−.77)	2 (.44)	16 (−2.59)	53 (.86)	10 (2.54)	14 (−1.89)	0 (−.22)	2 (−.19)	13 (2.66)	30 (1.45)	142
Fingers	61 (.01)	176 (−1.51)	29 (−1.69)	73 (−2.99)	1,573 (1.64)	2,733 (6.13)	225 (−6.71)	1,186 (−3.51)	1 (−3.50)	112 (−4.09)	333 (−4.15)	1,328 (2.67)	7,830
Leg	1 (.14)	2 (−.38)	1 (.81)	2 (.79)	20 (−.54)	20 (−3.61)	17 (7.12)	27 (2.51)	0 (−.20)	7 (3.94)	8 (1.33)	7 (−2.97)	112
Ankle	0 (−.60)	4 (2.87)	1 (1.89)	2 (2.23)	1 (−3.02)	10 (−1.75)	1 (−.42)	12 (1.97)	0 (−.13)	3 (2.66)	2 (−.06)	10 (.93)	46
Toe	1 (−.70)	8 (.91)	1 (−.03)	6 (2.14)	44 (−.97)	47 (−5.20)	15 (2.42)	71 (5.60)	2 (6.55)	9 (2.52)	16 (1.40)	32 (−1.70)	252
Other[2] or unknown	2 (1.22)	5 (1.51)	2 (2.31)	4 (2.67)	38 (3.75)	23 (−3.01)	11 (3.91)	11 (−1.69)	0 (−.20)	4 (1.67)	10 (2.24)	2 (−4.25)	112

[1] Adjusted standardized residual explained in text. It is the second of the two figures shown for each combination of variables.

[2] May include some cases involving previous categories which were not coded at sufficient detail to be specifically identified.

NOTE: Data are based on reports of current cases by 23 States.

In some cases, SDS data also permit evaluation of the medical and other compensable costs incurred by a State in settling the claims of injured workers. However, we can never measure the more important social costs and individual losses resulting from accidents which are too often preventable. □

——FOOTNOTES——

[1] See Norman Root and David McCaffrey, "Providing more information on work injury and illness," *Monthly Labor Review,* April 1978, pp. 16–21, for a complete discussion of the Supplementary Data System.

[2] In some States, a "closed" case means a case for which, in the reference year, the State decided the total benefits to be paid. States reporting in this manner were excluded from the analysis.

[3] Because of the reporting burden that would be involved, the BLS annual Survey of Occupational Injuries and Illnesses does not ask firms to describe the specific physical characteristics of their employees' injuries or illnesses.

[4] For a report on the survey, see *Occupational Injuries and Illnesses in the United States by Industry, 1977,* Bulletin 2047 (Bureau of Labor Statistics, 1980).

[5] One State (New Jersey) did not provide a 1977 estimate of lost workday cases for the annual survey. Consequently, New Jersey data are not used in obtaining the ratio of amputations to lost workday cases, although they are included in the other "current" case tables.

[6] Brian S. Everitt, *The Analysis of Contingency Tables* (New York, John Wiley and Sons, Inc., 1977), pp. 46–48; Shelby J. Haberman, "The Analysis of Residuals in Cross-Classified Tables," *Biometrics,* March 1973, pp. 205–20.

APPENDIX: Construction of adjusted standardized residuals

As previously indicated, adjusted standardized residuals (ASR's) are indicators of the cells in a cross-tabulation which have greater than expected values—values which probably represent a strong correlation between the two crossed variables. ASR's are constructed as follows.

Chi-square (X^2) values, which test whether the variables in the table are independent, are obtained by the formula:

$$X^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(n_{ij} - E_{ij})^2}{E_{ij}}$$

where n_{ij} refers to the observed values in the cell, and E_{ij} is the expected value in the cell. The expected value E_{ij} is the estimated value of the cell if the variables are independent. The larger the squared differences between the observed and expected values are, the larger the chi-square value becomes, and the more likely it is that the variables in the table are associated. E_{ij} is obtained by multiplying the cell's marginals (the total frequencies in the row (n_i) and column (n_j) in which the cell occurs) and dividing by the total number of cases in the table (N):

$$E_{ij} = \frac{n_i \, n_j}{N}$$

The adjusted standardized residuals indicate the most marked differences between the observed and expected values. *Residuals* refer to the differences between observed and expected values ($n_{ij} - E_{ij}$). These absolute differences, while useful, give an incomplete impression. For example, consider a cell where we expect 1,000 cases, but observe 1,200, and another cell where we expect 100 but observe 300. In both cases the absolute residual is 200, but in one cell the difference is 20 percent for 1,000 cases and in the other, 200 percent for 100 cases. Safety workers undoubtedly would be interested in the cell with 1,200 cases. But the cell with a 200-percent difference between the observed and expected values tends to show a stronger positive relationship between the cross-classified variables.

We can get a better perspective on the residuals by obtaining *standardized residuals* (e_{ij}), by dividing the residuals by the square root of the expected values:

$$e_{ij} = \frac{(n_{ij} - E_{ij})}{\sqrt{E_{ij}}}$$

In the case above, the standardized residual for the cell with 1,200 cases would be $(1{,}200-1{,}000)/\sqrt{1{,}000}$, or 6.32; and for the cell with 200 cases, $(300-100)/\sqrt{100}$, or 20.00. The standardized residual of 20.00 supports the reasonable conclusion that getting 300 cases where 100 are expected is more surprising than getting 1,200 where we expect 1,000.

The *adjusted* standardized residuals (d_{ij}) are obtained by dividing the standardized residuals by an estimate of their standard deviation, or square root of the variance v_{ij}, where:

$$v_{ij} = (1 - \frac{n_i}{N})(1 - \frac{n_j}{N})$$

Therefore,

$$d_{ij} = \frac{e_{ij}}{\sqrt{v_{ij}}}$$