

# Reporting of Occupational Injury and Illness in the Semiconductor Manufacturing Industry

## ABSTRACT

In the United States, occupational illness and injury cases meeting specific reporting criteria are recorded on company Occupational Safety and Health Administration (OSHA) 200 logs; case description data are submitted to participating state agencies for coding and entry in the national Supplementary Data System (SDS). We evaluated completeness of reporting (the percentage of reportable cases that were recorded in the company OSHA 200 log) in the semiconductor manufacturing industry by reviewing company health clinic records for 1984 of 10 manufacturing sites of member companies of a national semiconductor manufacturing industry trade association. Of 416 randomly selected work-related cases, 101 met OSHA reporting criteria. Reporting completeness was 60 percent and was lowest for occupational illnesses (44 percent). Case-description data from 150 reported cases were submitted twice to state coding personnel to evaluate coding reliability. Reliability was high ( $\kappa$  0.82–0.93) for “nature,” “affected body part,” “source,” and “type” variables. Coding for the SDS appears reliable; reporting completeness may be improved by use of a stepwise approach by company personnel responsible for reporting decisions. (*Am J Public Health* 1991; 81:85–89)

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### Introduction

Occupational injuries and illnesses represent an important health and economic cost in the United States. The US Department of Labor recorded more than six million cases of reportable occupational injuries and illnesses in 1987, including more than 50 million lost work days.<sup>1</sup> Health and economic consequences for individual workers due to occupational disorders range from trivial to devastating.

Epidemiologic study of occupational disorders has been hindered by the lack of a comprehensive reporting system providing reliable and consistent statistics.<sup>2</sup> The Occupational Safety and Health Act of 1970 attempted to address this problem by mandating the nationwide collection and analysis of statistics on occupational illnesses and injuries meeting specified reporting criteria.<sup>3</sup> The act defines an occupational injury as a disorder that results from an instantaneous exposure (e.g., an impact or fall) occurring in the work environment. Disorders resulting from work exposures that are not instantaneous are considered illnesses. Reporting is mandatory for all cases of occupationally related deaths, all occupational illnesses, and those occupational injuries meeting at least one of four reporting criteria; 1) injuries requiring medical treatment other than first aid, 2) restriction of work or motion, 3) termination or transfer to another job due to the injury, and 4) loss of consciousness.<sup>3</sup>

Each reportable case (and associated lost or restricted work days) is recorded in the company Occupational Safety and Health Administration (OSHA) 200 log and classified as an injury or one of the following seven categories of occupational illness: skin diseases, dust diseases

of the lungs, toxic respiratory conditions, systemic poisonings, disorders due to physical agents, disorders due to repetitive trauma, and other occupational illnesses. A sample of approximately 280,000 establishments is selected annually to forward a summary of information from the OSHA 200 log to the Bureau of Labor Statistics (BLS) for analysis and subsequent publication.<sup>4</sup> Additional information, including job title and description of the incident and resultant disorder, is recorded on an OSHA 101 form or equivalent state worker's compensation insurance form, which constitutes the Supplementary Data System (SDS). Coding for the SDS is performed by participating state agencies; in California the responsible agency is the California Department of Industrial Relations (CDIR).

In spite of the importance of these data, little research has been conducted to assess the completeness or reliability of reporting for OSHA-reportable conditions. We report here the results of an investigation of reporting of illness and injury in accordance with OSHA reporting criteria among members of the Semiconductor Industry Association (SIA). In addition, two samples of SDS forms were submitted to the CDIR to evaluate the reliability of coding decisions.

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TABLE 1—Recording by Industry of 101 Reportable Cases

Category <sup>a</sup>	Total Cases n (%)	Re- corded as illness n	Re- corded as injury n	Total Recorded n	Reporting Completeness %
Reportable injury	57 (56)	0	32	32	56
Reportable indeterminate	28 (28)	2	20	22	79
Reportable illness	16 (16)	2	5	7	44
Occupational death	0 (0)	0	0	0	—
Total	101 (100)	4	57	61	60

<sup>a</sup>Determined by authors based on Department of Labor criteria.<sup>3</sup>

*Reliability of SDS Classification*

We received 1,117 OSHA 101 or equivalent state workers' compensation forms from a random 50 percent sample of OSHA 200 cases from 1984, as reported previously.<sup>5</sup> Of these, a random sample of 150 forms was submitted to the CDIR without data on the nature, type, source, and body part involved that could identify the person or the company. The initial classifications were stored and the forms were resubmitted without identifying data for repeat classification. The CDIR nosologists received the materials in batches and were not aware that some of the forms had been previously classified. Reliability was calculated as the kappa statistic.<sup>6</sup> Statistical analysis was conducted on a VAX 11/750 computer using the Statistical Analysis System (SAS) software package.<sup>7</sup>

*Results*

Sixteen sites, representing 66,968 employees, were selected for review. Six sites were not included because they did not have daily clinic logs or supporting records for 1984 suitable for participation in this study, leaving 10 sites representing plants in six states distributed across the US. These 10 sites consisted of seven from the stratum of 10 large case contributors and three from the stratum of six facilities representing the remaining sites.

We reviewed 416 randomly selected work-related cases from the clinic logs. Personal employee health charts were available in 249 (60 percent) of these cases. These records were not available in the remaining cases because of the inability of the companies to locate the records because of loss, transfer, or termination of the employee. There were 101 cases (24 percent) that met reportability criteria for the OSHA 200 form. The median number of reportable cases per site was 8.5 (range: 0–29).

Of the 101 reportable cases, 57 (56 percent) were injuries, 28 (28 percent) were indeterminate cases that met the reporting criteria for injuries, and 16 (16 percent) were occupational illnesses (Table 1). Fourteen (88 percent) of the occupational illness cases represented skin conditions, and the remainder were due to cumulative trauma. Sixty-one (60 percent) of the 101 reportable cases were recorded on the company OSHA 200 form. The completeness of reporting ranged from 13 percent to 100 percent at the nine participating sites with reportable cases. No as-

*Methods*

*Population*

The SIA is a national trade association of semiconductor manufacturing firms (Standard Industrial Classification code 3674). In 1982, the SIA sponsored the development of the Occupational Health System (OHS), a prospective computerized data collection system operating in parallel with the governmental OSHA 200 reporting system. Sixteen companies comprising 37 plant sites and employing more than 96,000 workers, or approximately one-third of semiconductor manufacturing employees in the US in 1984,<sup>4</sup> participated in the OHS. All manufacturing sites participating in the OHS in 1984 agreed to participate in an evaluation of their recording practices.

*Company Health Record Review*

We evaluated the reporting completeness and reliability of case description data for 1984. Review of cases from the company clinic daily log was conducted at a sample of sites chosen on the basis of a stratified sampling scheme. The 10 sites contributing the most OSHA-reportable cases (median reported cases, 175; median number of employees, 5,951) and a random sample of six of the remaining 27 sites (median reported cases, 24; median number of employees, 920) were selected for site visits.

We examined the daily clinic log for 1984 and selected four work-related cases per month at random from each site. Only cases that the employer had previously determined to be work-related were sampled. When it was available, the abstracter also reviewed the OSHA 101 form (or

equivalent state form for the workers' compensation employer's first report), the form for the physician's first report, and the case's personal employee health clinic chart.

If the exposure or event causing the employee's disorder was considered by the abstracter to be instantaneous, the case was classified as an injury. All lacerations, contusions, sprains, strains, and thermal burns were presumed to represent injuries unless the records explicitly indicated that the exposure causing the disorder was not instantaneous. Cases that were likely to have resulted from exposures that were not instantaneous were classified as illnesses. Examples include contact dermatitis due to gloves or creams, acid burns on the hand discovered after the removal of a faulty protective glove, and disorders due to repetitive trauma. Cases in which it could not be determined whether the exposure causing the disorder was instantaneous (e.g., "acid burn on hand") were classified as indeterminate.

We defined the reportability of cases according to BLS guidelines applicable in 1984.<sup>3</sup> The reportability for indeterminate cases was decided according to criteria for occupational injuries. Reporting criteria for injuries and indeterminate cases and work-related death were assumed to be absent unless specifically noted otherwise in the records.

The OSHA 200 form was reviewed to determine if the reportable cases had been recorded. Reporting completeness was calculated as the percentage of cases meeting OSHA reporting criteria that was recorded in the company's OSHA 200 log.

**TABLE 2—Reliability of Classification for 150 Reportable Cases of Occupational Injury or Illness**

Classification Variable	Kappa
Nature of injury or illness	0.92
Strain, sprain	0.95
Cut, laceration, puncture	1.00
Chemical burn	0.87
Contusions, crushing injuries, bruise	0.96
Affected body part	0.93
Back	1.00
Finger(s)	0.97
Eye(s)	0.96
Hand (not wrist or fingers)	0.92
Source of injury or illness	0.83
Boxes, crates, cartons, cases	0.97
Hydrofluoric acid	0.96
Bodily motion	0.75
Floor	0.79
Type of injury or illness	0.82
Overexertion in lifting object	0.93
Contact with radiation, caustics, etc. (by skin absorption)	0.94
Fall onto walkway or working surface	0.78
Bodily reaction	0.75

sociation was observed between employee population size or the number of reportable cases at a site and reporting completeness. Because reporting completeness was similar in the two sample strata, the strata were combined for analysis.

Of the 61 reportable cases recorded on the OSHA 200 form, 32 (52 percent) were classified by the abstractor as recordable injuries, 22 (36 percent) were classified as recordable indeterminate cases, and 7 (11 percent) were classified as occupational illnesses (Table 1). Of the 7 illness cases that were reported, 5 (71 percent) were misclassified as occupational injuries. Three of these cases were occupational skin diseases and two were illnesses due to repeated trauma.

For the combined 85 cases of reportable injuries or reportable indeterminate cases, 55 (65 percent) were reportable because of the use of medical therapy beyond first aid and 33 (39 percent) were reportable because of restriction of work motion. Reporting completeness was 78 percent for restriction of work motion cases and 56 percent for medical therapy cases. Reporting completeness was lowest for illnesses. No cases of loss of con-

sciousness or termination or transfer due to an injury and no occupational deaths were observed.

Of the 40 reportable cases that were not recorded on company OSHA 200 logs, 25 (63 percent) were classified by the abstractor as reportable injuries, 9 (23 percent) were occupational illnesses, and 6 (15 percent) were reportable indeterminate cases. The most common reportability criteria among the injury and indeterminate cases were use of medical therapy other than first aid (24 cases) and restriction of work or motion (8 cases). All of the 9 unreported occupational illnesses represented skin disease cases.

#### *Reliability of SDS Classification*

The reliability of classification by the CDIR was calculated as the kappa statistic and varied from .82 for type of condition to .93 for affected body part (Table 2). There was little variation in the kappa values between categories within nature, part, type, and source variables.

#### *Discussion*

Occupational morbidity imposes an important health and economic burden on individual workers, employers, and society. Primary prevention plays an important role in minimizing this burden. Preventive measures, although generally more cost-effective than treatment, require directed use of resources, and accurate epidemiologic information is needed to guide the application of these resources. The BLS report of occupational injuries and illnesses offers the only nationwide statistics for occupational injuries and illnesses based on standardized reporting criteria. We report the results of our evaluation of reporting completeness within a large and important industry and the reliability of coding for case description data by a state agency participating in the SDS.

A major goal of this study was to evaluate the reporting completeness for conditions that the employer considered work related. Cases that were not recognized as work related would not have been included in the study. True occupational cases may be missed if the employee does not seek medical attention or if the treatment practitioner or employer does not recognize the occupational relationship. Failure to recognize an occupational etiology is particularly likely for illnesses due to chronic exposures and characterized by subtle manifestations or long latencies, such as cancer, neurologic disease, and reproductive disorders. Lack of severity,

incomplete medical evaluation, and inadequate recording practices may also lead to underreporting.

In the early 1980s OSHA implemented a site-inspection policy that focused inspections away from establishments that reported low injury rates, raising concern that this policy may promote underreporting. However, examination of these factors and estimation of the true rate of occupational injury and illness would have required active surveillance to capture true cases that would otherwise be undetected and were beyond the scope of this study.

Our findings suggest that the BLS data significantly underestimate incidence of occupational injuries and illnesses. If the 60 percent reporting completeness we observed for conditions recognized by the employer as work related is representative of other industries, the incidence may be nearly 70 percent higher than reported. The underestimation is most significant for occupational illnesses, for which the 44 percent reporting completeness we observed suggests that the incidence may be almost 130 percent higher than reported. The true incidence of occupational conditions is likely to be significantly higher, because the estimates calculated above are based upon observed reporting of conditions recognized by the employer as work related.

Among injury and indeterminate cases, the highest reporting completeness occurred for cases characterized by restriction of work or motion. Injuries and indeterminate cases characterized by the need for medical treatment were less likely to be recognized as reportable. Thus, BLS data are likely to be most valid for conditions such as injuries that directly affect the ability of a worker to perform a job.

The results of this investigation may have been affected by selection bias. The companies studied are members of a large trade association and may not be representative of this industrial sector with respect to reporting performance. Companies not belonging to the trade association may have fewer resources to devote to surveillance and prevention of occupational conditions. Thus, reporting completeness in the group we studied may be higher than for nonmembers. Because the firms participating in this study represent a large fraction of this important industrial sector, we do not believe that any selection bias would have seriously altered our findings and conclusions.

Information bias may also have affected our observed results. Personal employee health charts to supplement data contained in the clinic log were not available for approximately 40 percent of the 416 cases selected for review. Although the clinic logs were generally the most helpful sources of information, personal employee health charts could have contained information indicating a reportable condition. By not reviewing all of these, we may have overestimated reporting completeness. Reporting completeness for occupational illnesses may have been overestimated because indeterminate cases were considered reportable only if they met reporting criteria for injuries. In other words, some indeterminate cases not meeting reporting criteria for injuries may have actually been illness cases but would not have been recognized and classified as reportable in this study. In addition, we presumed that reporting criteria were absent unless they were specifically noted as present; incomplete or incorrect medical record entries could have contributed to erroneous classification with respect to reportability.

Although the influence of these potential biases is difficult to quantify, the data indicate that significant underreporting for occupational disorders, especially illnesses, occurred in the semiconductor manufacturing industry. The increased underreporting for occupational illnesses is significant because the semiconductor manufacturing industry is chemically intensive,<sup>8,9</sup> and illnesses represent a greater proportion of OSHA-reportable cases in this industry than in the manufacturing sector in general.<sup>10</sup> Although the absence of a control industry in this investigation limits comparison with other industries, underreporting has been documented in recent studies of other industries. Eisenberg and McDonald<sup>11</sup> observed an underreporting rate of approximately 20 percent in a pilot investigation of OSHA-reporting practices in 192 manufacturing establishments in Massachusetts and Missouri.

Other investigations have attempted to assess the true rates of occupational conditions. For occupational deaths, estimates of underreporting from 30 to 50 percent have been reported.<sup>12,13</sup> A recent investigation by Blanc and coworkers<sup>14</sup> evaluated the usefulness of occupational illness surveillance using Poison Control Center data. These investigators suggested that the true incidence of occupational illness is three to five times current estimates. Thus, significant underreporting is likely to occur in other manufac-

turing industries, and a review of underlying causes and possible remedies discussed here may be valuable for industry groups not represented in this investigation.

We also observed misclassification of occupational illnesses as injuries. This phenomenon illustrates important inconsistencies in the OSHA 200 reporting system. Specifically, all occupational illnesses must be reported under the system, regardless of severity, whereas occupational injuries are reported only if they meet specific criteria reflecting severity. Furthermore, classification of illness or injury depends on the exposure leading to the condition. If the exposure was "instantaneous" (a time period defined only by examples of a fall or blow in BLS reporting guidelines), the condition is viewed as an injury. Conditions resulting from all other (i.e., noninstantaneous) exposures are considered illnesses.

Thus, classification of injury and illness in the OSHA system is based on duration of exposure instead of on a biological index such as the nature or severity of the medical condition. Persons unfamiliar with this classification system might use a more biologic and intuitive approach and classify certain illnesses, such as repetitive trauma disorders or chemical burns, as injuries. In addition, the duration of exposure may not be precisely known, and reporting completeness will depend on the interpretation of incomplete or equivocal exposure information by the companies' reporting personnel. However, the majority of underreported or misclassified cases reported here were not equivocal; underreporting appeared due to inconsistent use of published reporting criteria addressing the clinical features of the case.

In spite of the limitations of this study, we have made several valuable observations on which to base specific recommendations. The OSHA data require company personnel at each facility to make case evaluation and classification decisions. Within an industry, the large number of facilities contributing cases introduces the potential of variable reporting practices between facilities, contributing to variability in the quality of the data. In contrast, the coding of clinical data entering the SDS is performed by a small number of trained personnel in a central state office. Our findings indicate that this practice is associated with high reliability of coding for clinical data. It would be impractical to submit all work-related cases to a central office for determination of reportability, and this responsibility is likely

to remain at the level of designated personnel at each facility. Reporting practices may be improved and made more uniform by focusing educational measures on these personnel. Education should emphasize recognition of occupational illnesses, for which underreporting was most significant in this study.

We recommend that recording personnel use a formal, stepwise process that forces response to the following pertinent questions to determine reportability of occupational conditions.

- Was the exposure instantaneous (e.g., a fall or a blow)? All cases for which the exposure was not instantaneous are reportable as occupational illnesses. Cases for which the exposure was instantaneous are injuries; the following additional questions must be addressed to evaluate their reportability.

- Was medical treatment other than first aid required, as defined in BLS reporting guidelines?

- Was restriction of work or motion involved that interfered with normal work activities?

- Was there loss of consciousness?

- Was the employee transferred or terminated due to the condition?

If the answer to any of the last four questions is affirmative, the injury is reportable. Regular review of selected cases would help assure consistency and validity of results.

We also recommend that studies evaluating reporting practices be conducted in other industrial sectors. These studies would expand the findings of the investigation reported here and provide a more broadly based picture of the accuracy of national occupational injury and illness data based on the OSHA 200 log. Studies focused on specific occupational conditions should also be undertaken to evaluate the completeness and accuracy of reporting for the OSHA 200 system using independent data sources, such as cancer registries, workers' compensation records, hospital discharge data bases,<sup>15</sup> Poison Control Centers,<sup>14</sup> and occupational health clinics.<sup>16</sup> Accurate surveillance methodology is especially important for occupational illnesses, which are poorly captured by the OSHA 200 system.<sup>13</sup> Finally, case reportability criteria, currently constrained by the Occupational Safety and Health Act, should be reviewed and revised to conform to biological criteria rather than to duration of exposure. □

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