ORIGINAL ARTICLE

Relation between sick leave and selected exposure variables among women semiconductor workers in Malaysia

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Occup Environ Med 2003;**60**:262–270

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Accepted 10 July 2002

Aims: To determine the relation between sick leave and selected exposure variables among women semiconductor workers.

Methods: This was a cross sectional survey of production workers from 18 semiconductor factories. Those selected had to be women, direct production operators up to the level of line leader, and Malaysian citizens. Sick leave and exposure to physical and chemical hazards were determined by self reporting. Three sick leave variables were used; number of sick leave days taken in the past year was the variable of interest in logistic regression models where the effects of age, marital status, work task, work schedule, work section, and duration of work in factory and work section were also explored.

Results: Marital status was strongly linked to the taking of sick leave. Age, work schedule, and duration of work in the factory were significant confounders only in certain cases. After adjusting for these confounders, chemical and physical exposures, with the exception of poor ventilation and smelling chemicals, showed no significant relation to the taking of sick leave within the past year. Work section was a good predictor for taking sick leave, as wafer polishing workers faced higher odds of taking sick leave for each of the three cut off points of seven days, three days, and not at all, while parts assembly workers also faced significantly higher odds of taking sick leave.

Conclusion: In Malaysia, the wafer fabrication factories only carry out a limited portion of the work processes, in particular, wafer polishing and the processes immediately prior to and following it. This study, in showing higher illness rates for workers in wafer polishing compared to semiconductor assembly, has implications for the governmental policy of encouraging the setting up of wafer fabrication plants with the full range of work processes.

Occupational health problems of the semiconductor industry are better documented in developed countries compared to developing countries. LaDou[1] has used data in California in the early to mid 1980s to show that work loss due to occupational illness as a percentage of all work loss cases was higher among workers in the electronics industry when compared to the entire manufacturing sector; and also higher among workers in the semiconductor fabrication sector when compared to other sectors in electronics. Occupational exposure to hazardous chemicals has been identified as the primary risk faced by workers.[2]

In developing countries, occupational health in the electronics industry has not been researched as systematically as that in developed countries. Nevertheless, there have been studies describing occupational health problems among women electronics workers in developing countries.[3 4] Lin's study[5] comparing women production and clerical workers in the electronics industry in Malaysia and Singapore in 1983 found that production workers were more likely to experience injuries and illnesses and take sick leave, and were also more likely to report specific health complaints. Since Lin's study, which covered a total of 903 women workers, there have been no more studies of a comparable size on the occupational health of women workers in the electronics industry in Malaysia. Specifically, there have been no studies conducted on sickness absence in the semiconductor industry in Malaysia.

This is a significant omission considering the importance of sickness absence as an indicator of productivity that is commonly used in human resource planning, not to mention its use as a global measure of illness among the workforce in general. Furthermore, in Malaysia, the electronics industry

Main messages

- Wafer polishing and parts assembly workers face higher odds of taking sick leave within the past year, even after adjusting for age, marital status, work schedule, and duration of working in the factory.
- Semiconductor workers who complain of working in conditions of poor ventilation and of smelling chemicals, face higher odds of taking sick leave within the past year, even after adjusting for age, marital status, work schedule, and duration of working in the factory.

Policy implications

- The Malaysian government should develop a policy on occupational health and safety management systems, as well as guidelines specifically tailored for wafer fabrication factories, the setting up of which it currently encourages.
- The Malaysian government should set up a system for collecting routine data such as sick leave, which could be collated and analysed across industries, and used to indicate areas and periods of increased risks.

Abbreviations: EOL, end of line; FOL, front of line; MOL, middle of line; MIDA, Malaysian Industrial Development Authority was the leading industry in terms of manufacturing value added and the largest contributor to manufactured exports in 2000,[6] as well as a major employer, and the semiconductor industry is the major subsector within the electronics sector.

Semiconductor production begins with wafer fabrication, followed by semiconductor assembly. Wafer fabrication is a capital intensive process involving sophisticated technology, and is usually carried out in developed countries, where the water and power supply infrastructure is adequate to meet its exacting demands. Semiconductor assembly, on the other hand, involves the use of less sophisticated technology and procedures, but is more labour intensive. Since the 1970s, multinational electronics companies have relocated the production processes downstream from wafer fabrication to offshore sites in developing countries, where labour costs are considerably lower.

In Malaysia, the semiconductor industry is dominated by semiconductor assembly factories. Wafer fabrication is not carried out in its entirety, but there are a few wafer fabrication factories which carry out a specific portion of the wafer fabrication process only, in particular, the wafer polishing part and the parts immediately prior and subsequent to it. Wafers are brought into the country to undergo this part of the process, after which they are sent out of the country for subsequent processing. Wafers used in the semiconductor assembly factories are imported from abroad.

In 1998–2001, a study entitled "Reproductive Health Hazards and its Management in the Manufacturing Sector" was carried out, covering five manufacturing industries—automobile, steel, batik, textile, and semiconductor. Its aim was to collect baseline data on occupational health of production workers, and health policies and programmes at the workplace; although the focus was on reproductive health hazards. Data from the semiconductor study are used in this paper to determine the relation that exists between occupational exposures and ill health. The sick leave taken by workers is assumed to be generally indicative of ill health. Exposures to physical and chemical hazards are determined by self reporting.

SUBJECTS AND METHODS

The Malaysian Industrial Development Authority (MIDA) list of electronics factories (31 August 1998) was used for selecting the factories. All factories that were classified as semiconductor factories in two geographical clusters were contacted for verification of status, with a final list of 24 eligible factories. The management of these factories were invited to participate in the survey; six declined, resulting in a total of 18 participating factories—that is, a 75% participation rate.

Data collection was carried out from July 1999 to March 2000. In each factory, the researchers were first briefed by the relevant personnel on work processes, hazards, and health and safety precautions taken. The researchers were then taken on a brief walk-through survey of the plant. For the workers' survey, the researcher requested the management to provide a 10% random sample of women workers with the criteria that they must be Malaysian citizens, have worked for one year or more in the present factory, and are direct production line workers up to the level of line leaders only. Factories with fewer than 300 women workers were asked to select at least 30 workers, and those with more than 2000 workers were asked to select only 200 workers. It was emphasised to the management that the selection should be random, and that every work process should be represented.

The selected workers were given time off from production to participate in the survey. The participating workers were asked to fill in a questionnaire in groups, after having been briefed by the researchers. Individual identification was not required in the questionnaire, and the researchers also reassured the workers that their individual identities would not be revealed, and that only aggregate data would be used. The workers took about 45 minutes to an hour to complete the questionnaires.

The instrument used was a structured self administered questionnaire which included questions on sociodemographic factors, work factors, physical working conditions, chemical usage, and sick leave. The outcome indicators for illness were obtained from three questions on sick leave: (1) any health problems that caused absence from work within the past month (yes or no); (2) whether any sick leave was taken for a continuous period of one week or more within the past year (yes or no); and (3) the number of days of sick leave taken within the past year.

Exposure to chemical hazards was measured from two questions: (1) whether chemicals were used by the workers (yes or no); and (2) whether or not there was any smell of any chemicals or dust while working (yes or no). The variables for exposure to physical hazards were a combination of two questions. First, the workers were asked if they felt that they were exposed to various physical hazards (yes or no), and second, whether they felt satisfied with various aspects of their physical working conditions (satisfied, dissatisfied, or not relevant). Only workers who answered yes to the first question and dissatisfied to the second were considered as being exposed to the particular physical hazard. Other general exposure variables used were the length of employment in the present factory, work section, and the length of time worked there. Age, marital status, work task (as categorised by the level of automation), and work schedule were considered as possible confounders.

Data analysis was carried out using the SPSS (version 10.0) software package. The relations between exposure and outcome variables were tested by *t* test, χ^2, and odds ratio. Multivariate analysis was carried out by logistic regression, the models of which included exposure and confounding variables that were found to be significantly related in the bivariate analysis.

RESULTS

Factories and work processes

The 18 participating factories classified under the semiconductor industry consisted of 15 semiconductor assembly factories and three wafer fabrication factories. Seven of the semiconductor assembly factories were large factories with more than 1000 employees each, four were medium sized with between 500 and 1000 employees, and four were small, with fewer than 500 employees. The three wafer fabrication factories were medium sized.

The initial wafer fabrication processes of crystal growing are not carried out in Malaysia. In the three wafer fabrication factories studied, the processes begin with mounting the imported ingots onto rods. These are sliced into wafers, which are then put through various processes—etching, lapping, annealing, grinding, sand blasting—to achieve clean and smooth mirror surfaces. The wafers are then transferred out of the country for photomasking and subsequent processes.

In semiconductor assembly, imported wafers are diced, and the die are then processed, attached, bonded with wires, and tested. This part of the assembly is called the front of line (FOL), and it is carried out in clean rooms. The middle of line (MOL) processes are for encapsulating the exposed die so as to prevent contamination. The encapsulated die go through processes of forming and trimming, soldering, and marking. The end of line (EOL) consists primarily of processes designed to test the chip in various ways, and includes electrical and memory testing, burn-in testing, as well as final visual inspection.

Table 1 Study population

	Distribution of respondents (n=968) No.	%
Ethnicity		
Malay	734	75.8
Non-Malay	234	24.2
Marital status		
Unmarried	437	45.1
Married	495	51.1
Divorced and widowed	36	3.8
Age group (y)		
<25	303	31.3
25–34	328	33.9
35–44	293	30.3
45–54	44	4.5
Mean (SD)	30.5 (7.9)	
Education level		
No formal education	6	0.6
Primary	63	6.5
Lower secondary	260	26.9
Upper secondary and higher	639	66.0
No. of years worked in present factory		
1–2	231	23.9
>2–5	246	25.4
>5–10	161	16.6
>10–20	245	25.3
>20	85	8.8
Mean (SD)	8.9 (7.5)	
Job designation		
Operator	890	91.9
Line leader	78	8.1
Work schedule		
Fixed shifts	90	9.3
Rotating 8 hour shift	586	60.6
Rotating 12 hour shift	292	30.1
Work section		
Wafer polishing	93	9.6
Semiconductor assembly		
Front of line	184	19.0
Middle of line	182	18.8
End of line	461	47.6
Parts assembly	48	5.0
Type of work task		
Automated	476	49.2
Semi-automated	138	14.3
Manual	126	13.0
Inspection	192	19.8
Supervisory	36	3.7
No. of years worked in present section		
1–2	347	35.8
>2–5	283	29.2
>5–10	174	18.0
>10–20	137	14.2
>20	27	2.8
Mean (SD)	6.0 (5.8)	

The semiconductor assembly factories in the study as a whole have all the processes from front of line to end of line. The big and medium factories have most of the processes, although some parts of the production may be contracted out to smaller factories. The four small factories only have certain parts of the assembly process, such as two factories which only carry out burn-in testing. A few of the semiconductor assembly factories also have lines carrying out diode assembly and the assembly of final products, but these constitute only a minor part of the production process.

Walk-through survey findings: exposures and working conditions

From the walk-through survey, noise was found to be present in all areas, but was particularly a problem in the wafer fabrication factories and the middle of line semiconductor assembly processes. Extreme cold was experienced primarily in the clean rooms where the front of line semiconductor assembly processes took place; but some of the end of line testing areas were also very cold. Heat was found to be a problem primarily in the moulding processes as well as in the burn-in testing areas; while radiation was contained in a few specific areas. Poor ventilation and lighting was noticeable only in very few areas, primarily in the smaller plants.

It was observed that chemicals were widely used throughout the processes, but the level of automation with enclosed work processes was very high. Chemicals were more obviously evident in the wafer fabrication factories and in the middle of line areas, particularly where moulding and plating were carried out. The chemicals that were used in wafer polishing included hydrochloric and hydrofluoric acids, hydrogen peroxide, and ammonia. In the middle of line processes, the chemicals included epoxy resin, mould compound, as well as various acids and alcohols. Isopropyl alcohol (IPA) and acetone were commonly used throughout the entire semiconductor assembly process.

Study population

A total of 968 women workers were in the final sample, of which the majority (90%) were from semiconductor assembly factories (65% from large factories, 16% from medium sized factories, and 9% from small factories), and 10% were from wafer fabrication factories.

The workers who participated in the study were largely Malays (75.8%), and slightly more than half (51.1%) were married. They were fairly well distributed in the three age categories: <25 years (31.3%), 25–34 years (33.9%), and 35–44 years (30.3%), with a mean of 30.5 (7.9) years, and a range of 18–54 years (table 1). It was a generally well educated group: two thirds (66%) had achieved an upper secondary education or higher; only 0.6% had not had any formal education.

The number of years that the workers had worked in their present factory spanned a wide range (1–31 years), with a mean of 8.9 (7.5) years, and a median of 6.0 years. Close to 50% of the group had worked up to five years only (23.9% for 1–2 years and 25.4% for 2–5 years); a substantial minority (8.8%) had worked for more than 20 years.

The workers were all direct line operators, with 8.1% of them having additional responsibilities as line leaders. The majority (60.6%) worked a rotating eight hour shift; 30.1% worked a rotating 12 hour shift, and 9.3% worked in fixed day shifts. The rotating 12 hour shift is usually combined with a fortnightly work schedule of four days work, three days rest, three days work, and four days rest; both the rotating eight hour and the fixed day shifts function on a six day work week with a fixed rest day on Sunday.

All work processes present in the factories were represented by the sample. A large proportion of the sample (47.6%) was from the end of line processes in semiconductor assembly, many of which were inspection and testing processes. Automation appeared to dominate, with almost half of the workers (49.2%) working in tasks that were fully automated and 14.3% in tasks that were semi-automated. In automated work tasks, workers load units into machines for processing, and then unload them again when the process is done. In between, they usually look after several machines, fixing the settings by computer and checking when warning buzzers go off. In semi-automated work tasks, workers are required to handle units manually in between machine operated processes.

The number of years that workers had worked in their present work section is generally lower than the number of years worked in present factory, with 35.8% having worked for only 1–2 years. Among the large factories, there was one where a section was opened within the past two years only; workers were transferred from within the factory to work in this new section, accounting for the high percentage in the 1–2 year category.

Table 2 Percentage distribution of age, working duration in present factory, and marital status by work section (n=968)

	Work section				
	WF (n=93)	FOL (n=184)	MOL (n=182)	EOL (n=461)	PA (n=48)
Age group					
<25	21 (22.6)	59 (32.1)	57 (31.3)	155 (33.6)	11 (22.9)
25–34	38 (40.9)	59 (32.1)	65 (35.7)	144 (31.2)	22 (45.8)
35–44	27 (29.0)	63 (34.2)	54 (29.7)	137 (29.7)	12 (25.0)
45–54	7 (7.5)	3 (1.6)	6 (3.3)	25 (5.4)	3 (6.3)
Mean (SD)	31.4 (7.8)	30.4 (7.8)	30.0 (7.6)	30.5 (8.2)	30.8 (7.6)
No. of years worked					
1–2	12 (12.9)	50 (27.2)	50 (27.5)	113 (24.5)	6 (12.5)
>2–5	33 (35.5)	32 (17.4)	37 (20.3)	128 (27.8)	16 (33.3)
>5–10	13 (14.0)	30 (16.3)	25 (13.7)	77 (16.7)	16 (33.3)
>10–20	27 (29.0)	47 (25.5)	63 (34.6)	100 (21.7)	8 (16.7)
>20	8 (8.6)	25 (13.6)	7 (3.8)	43 (9.3)	2 (4.2)
Mean (SD)	9.9 (7.8)	9.8 (8.1)	9.0 (7.4)	8.5 (7.4)	7.8 (6.0)
Marital status					
Single	32 (34.4)	84 (45.7)	88 (48.4)	210 (45.6)	23 (47.9)
Married	59 (63.4)	91 (49.5)	90 (49.5)	233 (50.5)	22 (45.8)
Divorced/widowed	2 (2.2)	9 (4.9)	4 (2.2)	18 (3.9)	3 (6.3)

WF, wafer polishing; FOL, semiconductor assembly front of line; MOL, semiconductor assembly middle of line; EOL, semiconductor assembly end of line; PA, parts assembly.

Table 3 Exposure to chemical and physical hazards and sick leave taken

	Distribution of respondents (n=968)	
	No.	%
Exposed to chemical hazards		
Chemicals used in work process	405	41.8
Smell chemicals while working	309	31.9
Exposed to physical hazards		
Noise	383	39.6
Cold	266	27.5
Insufficient ventilation	94	9.7
Heat	84	8.7
Insufficient lighting	57	5.9
Radiation	56	5.8
Exposed to/dissatisfied with physical conditions		
Noise	282	29.1
Temperature—too cold	155	16.0
Poor ventilation	61	6.3
Temperature—too hot	55	5.7
Poor lighting	20	2.1
Have taken sick leave in the past one month	170	17.6
Have taken sick leave for one week or more continuously within the past year	27	2.8
No. of days of sick leave taken in the past year		
0	480	49.6
1–3	281	29.0
4–7	135	13.9
>7	72	7.5
Mean no. of days of sick leave taken in the past year (SD)	2.5 (5.4)	

The mean age of workers in each of the five work sections did not differ widely, ranging from 30.0 (7.6) to 31.4 (7.8) years (table 2). The mean number of years worked in the present factory had a wider range, from 7.8 (6.0) in parts assembly to 9.9 (7.8) in wafer polishing. Wafer polishing had more married women workers (63.4%) compared to semiconductor assembly (49.5% each in FOL and MOL, and 50.5% in EOL), while parts assembly had the lowest proportion of married women (45.8%).

Exposure to chemical and physical hazards and sick leave

When the workers were asked whether chemicals were used in the work processes they were involved in, 41.8% answered affirmatively and 31.9% said that they smelt the chemicals while working (table 3). This reflects that the workers were aware that chemicals were used in their work processes even though they might not have been able to detect them by smell.

The physical hazard identified by the highest proportion of workers was noise, followed by cold. While 39.6% said that they were exposed to noise, only 29.1% were exposed as well as dissatisfied with the noisy working conditions. Likewise, there were only 16.0% who were both exposed as well as dissatisfied with the temperature being too cold, although 27.5% had said that they were exposed to low temperatures.

Overall, the prevalence of sick leave within the past month was 17.6%, and the proportion who had taken sick leave for one week or more continuously within the past year was 2.8%, indicating that serious illness or injury of lengthy duration was less frequently experienced. On average, the workers had taken 2.5 (5.4) days of sick leave within the past year; but 49.6% had not taken any sick leave at all.

Table 4 Differences in mean age and mean number of years worked in factory and current section between those who took sick leave and those who did not

	Duration of sick leave taken in the past year					
	⩽7 days (n=896)	>7 days (n=72)	⩽3 days (n=761)	>3 days (n=207)	0 (n=480)	⩾1 day (n=488)
Mean age (y)	30.3	32.6	30.3	31.3	30.1	30.9
t	2.4		1.5		1.5	
p	0.018*		0.130		0.142	
Mean no. of years worked in factory	8.8	11.2	8.7	9.9	8.7	9.2
t	2.7		2.0		1.1	
p	0.008**		0.046*		0.288	
Mean no. of years in current section	5.9	6.7	5.8	6.7	5.6	6.3
t	1.2		1.9		1.9	
p	0.250		0.060		0.054	

*p<0.05, **p<0.01.

Table 5 Association between duration of sick leave taken in the past year and marital status, work section, work task, and work schedule (n=968)

	Duration of sick leave taken in the past year (%)					
	⩽7 days	>7 days	⩽3 days	>3 days	Never taken	⩾1 day
Marital status						
Single (n=437)	95.7	4.3	85.1	14.9	57.0	43.0
Married (n=495)	89.9	10.1	72.9	27.1	43.0	57.0
Divorced/widowed (n=36)	91.7	8.3	77.8	22.2	50.0	50.0
	χ^2=11.2 p=0.004**		χ^2=20.6 p=0.000***		χ^2=18.1 p=0.000***	
Work section						
WF (n=93)	86.0	14.0	58.1	41.9	30.1	69.9
FOL (n=184)	96.2	3.8	81.5	18.5	56.5	43.5
MOL (n=182)	91.8	8.2	80.2	19.8	52.2	47.8
EOL (n=461)	92.4	7.6	80.5	19.5	51.2	48.8
PA (n=48)	95.8	4.2	83.3	16.7	35.4	64.6
	χ^2=10.2 p=0.037*		χ^2=26.2 p=0.000***		χ^2=22.5 p=0.000***	
Work task						
Automated (n=476)	94.1	5.9	80.7	19.3	52.1	47.9
Semi-automated (n=138)	87.0	13.0	73.2	26.8	41.3	58.7
Manual (n=126)	92.1	7.9	77.8	22.2	43.7	56.3
Inspection (n=192)	92.2	7.8	77.6	22.4	51.6	48.4
Supervisory (n=36)	97.2	2.8	80.6	19.4	58.3	41.7
	χ^2=9.19 p=0.056		χ^2=3.87 p=0.425		χ^2=8.17 p=0.086	
Work schedule						
Fixed shift (n=90)	95.6	4.4	80.0	20.0	43.3	56.7
Rotating 8 hour shift (n=586)	91.6	8.4	76.6	23.4	47.3	52.7
Rotating 12 hour shift (n=292)	93.5	6.5	82.2	17.8	56.2	43.8
	χ^2=2.27 p=0.322		χ^2=3.71 p=0.156		χ^2=7.72 p=0.021*	

*p<0.05, **p<0.01, ***p<0.001.

Of the three indicators, the number of sick leave days taken within the past year was considered to be the variable that would be most useful for long term occupational health management planning. As such, further analysis was carried out to identify the exposure variables that are associated with it.

General predictors for number of sick leave days

The number of sick leave days taken within the past year was analysed at three cut off points, these being seven days or less versus more than seven days, three days or less versus more than three days, and one day or more versus not having taken any sick leave. The workers who had taken more than seven days sick leave within the past year were significantly older ($p < 0.05$), and had worked more years in the factory than those who had taken seven days or less ($p < 0.01$) (table 4). Furthermore, those who had taken more than three days sick leave had worked significantly longer in the factory than those who had taken only three days or less ($p < 0.05$), but although they were also older, this difference was not significant. The mean number of years worked in the current section was not significantly different between those who took more and those who took less sick leave.

Marital status was a significant predictor of sick leave (table 5). Higher proportions of married women were found to have taken more sick leave than single, divorced, or widowed women, whether the cut off was at seven days ($p < 0.01$), three days ($p < 0.001$), or one day ($p < 0.001$). The associations between work section and sick leave were also significant, with consistently higher proportions of wafer polishing workers taking more sick leave than workers in the other work sections ($p < 0.05$ at the seven day cut off, and $p < 0.001$ at the three and one day cut offs). The associations between work task and sick leave were not significant, although workers in semi-automated tasks were consistently the highest proportions taking more sick leave, and workers in both semi-automated and manual tasks took more sick leave

Table 6 Odds ratios of having taken sick leave for more than seven days in the past year for selected exposure variables (n=968)

	Took >7 days sick leave within past year			
Exposure variables	Odds ratio	95% CI	Adjusted odds ratio	95% CI
Work section				
Wafer polishing	4.11	1.58 to 10.69	3.00	1.11 to 8.09
Semiconductor assembly				
Front of line	–	–	–	–
Middle of line	2.27	0.90 to 5.71	1.59	0.60 to 4.21
End of line	2.08	0.91 to 4.77	2.02	0.86 to 4.72
Parts assembly	1.10	0.22 to 5.47	1.06	0.21 to 5.36
Chemical hazards				
Use chemicals in work process	1.61	1.00 to 2.61	–	–
Smell chemicals (n=405)	1.68	1.03 to 2.74	1.50	0.86 to 2.61
Exposed to/dissatisfied with conditions				
Temperature—too hot	1.90	0.83 to 4.37	–	–
Temperature—too cold	1.70	0.96 to 3.01	–	–
Noise	2.07	1.27 to 3.37	1.69	0.98 to 2.89
Poor lighting	3.24	1.05 to 9.95	1.56	0.43 to 5.66
Poor ventilation	3.05	1.51 to 6.16	1.73	0.74 to 4.03

Adjusted odds ratios were obtained by logistic regression analysis with the covariates that were significantly related to the dependent variable. These were age, marital status, no. of years worked in factory, work section, smell chemicals, noise, poor lighting, and poor ventilation.

Table 7 Odds ratios of having taken sick leave for more than three days in the past year for selected exposure variables (n=968)

	Took >3 days sick leave within past year			
Exposure variables	Odds ratio	95% CI	Adjusted odds ratio	95% CI
Work section				
Wafer polishing	3.61	1.52 to 8.56	3.27	1.35 to 7.92
Semiconductor ssembly				
Front of line	1.13	0.49 to 2.64	1.18	0.50 to 2.81
Middle of line	1.23	0.53 to 2.86	1.07	0.45 to 2.54
End of line	1.21	0.55 to 2.68	1.33	0.59 to 3.01
Parts assembly	–	–	–	–
Chemical hazards				
Use chemicals in work process	1.62	1.19 to 2.21	1.34	0.78 to 2.30
Smell chemicals (n=405)	1.59	1.15 to 2.18	1.26	0.72 to 2.21
Exposed to/dissatisfied with conditions				
Temperature—too hot	1.55	0.85 to 2.84	–	–
Temperature—too cold	1.14	0.75 to 1.71	–	–
Noise	1.29	0.93 to 1.79	–	–
Poor lighting	3.10	1.27 to 7.58	1.74	0.63 to 4.80
Poor ventilation	2.38	1.39 to 4.09	1.63	0.87 to 3.06

Adjusted odds ratios were obtained by logistic regression analysis with the covariates that were significantly related to the dependent variable. These were marital status, no. of years worked in factory, work section, use chemicals in work process, smell chemicals, poor lighting, and poor ventilation.

than workers in automated tasks. The distribution of workers on different work schedules taking sick leave was not consistent over the three cut offs. Nevertheless, the association between work schedule and taking at least one day of sick leave was found to be significant, with workers on the 12 hour rotating shift having the lowest proportion ($p < 0.05$).

Odds ratios for having taken more sick leave days

The three cut off points for the taking of sick leave was further explored for their associations with various exposure variables. In testing the odds of having taken more than seven sick leave days in the past year, it was found to be significantly elevated for wafer polishing workers (odds ratio (OR) 4.11, 95% confidence interval (CI) 1.58 to 10.69), workers who smelt chemicals (OR 1.68, 95% CI 1.03 to 2.74), and those who were exposed to noise (OR 2.07, 95% CI 1.27 to 3.37), poor lighting (OR 3.24, 95% CI 1.05 to 9.95), and poor ventilation (OR 3.05, 95% CI 1.51 to 6.16) (table 6).

Adjusted odds ratios were obtained by logistic regression analysis in a model that included age, number of years worked in factory, marital status, and these significantly associated exposure variables (table 6). After adjustment, the only variable that remained significantly associated was wafer polishing workers, who had three times higher odds (95% CI 1.11 to 8.09) of having taken more than seven days of sick leave within the past year.

Likewise, the odds of taking more than three sick leave days in the past year was found to be higher for wafer polishing workers even after adjusting (OR 3.27, 95% CI 1.35 to 7.92) (table 7). Finally, the adjusted odds of having taken any sick leave at all in the past year was found to be significantly higher for workers in wafer polishing (OR 2.49, 95% CI 1.44 to 4.32) and parts assembly (OR 2.23, 95% CI 1.12 to 4.45), and for those exposed to poor ventilation (OR 2.30, 95% CI 1.25 to 4.25) and smelt chemicals (OR 1.64, 95% CI 1.01 to 2.67) (table 8).

Table 8 Odds ratios of having taken sick leave in the past year for selected exposure variables (n=968)

	Took sick leave within past year			
Exposure variables	Odds ratio	95% CI	Adjusted odds ratio	95% CI
Work section				
Wafer polishing	3.02	1.78 to 5.13	2.49	1.44 to 4.32
Semiconductor assembly				
Front of line	–	–	–	–
Middle of line	1.19	0.79 to 1.80	0.95	0.61 to 1.47
End of line	1.24	0.88 to 1.75	1.33	0.93 to 1.89
Parts assembly	2.37	1.23 to 4.59	2.23	1.12 to 4.45
Chemical hazards				
Use chemicals in work process	1.53	1.18 to 1.98	1.06	0.67 to 1.67
Smell chemicals (n=405)	1.62	1.23 to 2.13	1.64	1.01 to 2.67
Exposed to/dissatisfied with conditions				
Temperature—too hot	1.39	0.80 to 2.42	–	–
Temperature—too cold	0.97	0.69 to 1.36	–	–
Noise	1.17	0.89 to 1.54	–	–
Poor lighting	1.85	0.73 to 4.68	–	–
Poor ventilation	2.95	1.64 to 5.29	2.30	1.25 to 4.25

Adjusted odds ratios were obtained by logistic regression analysis with the covariates that were significantly related to the dependent variable. These were marital status, work section, work schedule, use chemicals in work process, smell chemicals, and poor ventilation.

DISCUSSION

Exposure to chemical and physical hazards

Observations from the walk-through surveys only provided a cursory, qualitative assessment of occupational hazards. Nevertheless, they validated the results of the workers' survey in confirming that noise and cold temperature, the exposures reported by the highest proportions of respondents, were indeed the most widespread. Radiation, poor ventilation, and poor lighting, observed only in limited areas, were likewise reported by smaller proportions of the respondents.

The proportion saying that chemicals were used by them was surprisingly low, and could be indicative of the large numbers of respondents working at inspection and testing processes. It might also reflect that workers who were monitoring machines in fully automated processes did not consider themselves to be working with chemicals, because in fully automated machines, even though chemicals were used, they were enclosed.

Sick leave

The number of sick leave days taken in the past year is the variable of interest because it is considered to be the most suitable for use in planning and management. Compared to the variable of taking sick leave in the past month, it represents a longer time period and is therefore less subject to short term fluctuations. It is also more suitable than the variable of taking sick leave continuously for more than seven days, which is a measure of severe illness, and is expected to be less frequent among a working population. The number of sick leave days taken in the past year, in measuring the frequency of illness over a long period, would be most suitable for reflecting recurrent but mild illnesses experienced by workers with low level exposures to occupational hazards and pressures, as may be expected in the semiconductor industry.

Nevertheless, using self reported absence data to reflect illness has many inherent problems, including inaccuracies in recall, lack of verification that sick leave taken was indeed caused by illness, different thresholds to taking sick leave, and possible confounding effects of other social, psychological, and work organisational factors that impinge on the taking of sick leave. In this study, one work organisational factor that could affect the taking of sick leave is the use of a disincentive—that is, the attendance allowance that is added to the monthly pay packet if the worker had not taken sick leave in the preceding month. In all the factories studied, workers' basic wages were supplemented by allowances; of the 18 factories in this study, 14 paid an attendance allowance.

Association between exposure and sick leave

The interpretation of data on various exposures relating to sick leave is further complicated by the multiple factors that contribute to it. In this study, mean age was significantly higher for workers who had taken more than seven days sick leave; and marital status was found to be a significant confounder for sick leave at each of the three cut offs—seven days, three days, and never taken. Other studies have also shown higher rates of sick leave among older workers,[7 8] and marital status to be a significant confounder for sick leave.[8] The relation between marital status and sick leave should be further investigated as it could be traced to many reasons, such as different social roles and responsibilities, the lack of social and family support, or the lack of social service provision for families.

Duration of work in the factory or in current work section may be considered either as confounders or as crude indicators of exposure to occupational hazards. Although the number of years worked in the factory was found to be a significant confounder among those who had taken more than seven, and three sick leave days, the number of years worked in current work section was not. Nevertheless, it should be noted that working duration itself could be confounded by age.

In general, higher odds for having taken sick leave were seen among workers who face exposures to occupational hazards, as measured by work section and self reported exposures to chemical and physical hazards. Although some of these odds were significantly higher, most were not significant after adjusting for the confounders of age, marital status, and years of working, indicating that self reported exposure to chemical and physical hazards could not independently predict the taking of sick leave. Poor ventilation was an exception, as it was found to be a predictor of having taken sick leave within the past year; but it should be noted that there were only 61 respondents who had been exposed to poor ventilation. Those who reported smelling chemicals also had significantly higher odds of taking sick leave after adjusting for confounders; but the level of significance was marginal.

Work section was a good predictor for taking sick leave, as wafer polishing workers faced higher odds of taking sick leave for each of the three cut off points of seven days, three days, and not at all. Parts assembly workers also faced significantly higher odds of taking sick leave at all, but again, there were only 53 respondents who were in parts assembly. One obvious factor to investigate would be the higher exposures to chemical hazards that were observed in wafer fabrication and middle of line semiconductor assembly work processes, which would have a logical consequence in the higher levels of illness seen among wafer polishing workers compared to semiconductor assembly workers. On the other hand, a consistent pattern could not be demonstrated to distinguish among the various work sections in semiconductor assembly. Furthermore, if chemical exposure is to be singled out, one would expect workers in fully automated work tasks to have lower exposures than those in manual or semi-automated tasks, and hence to have less sick leave days. Although this pattern was indeed observed, the relation between sick leave and work task, as reflected by the level of automation, was not found to be significant.

There could be other work organisational factors that account for the differences seen between work sections. Work schedule was investigated, but no consistent pattern was observed for the three sick leave cut offs, although significantly lower proportions of workers on a rotating 12 hour shift were found to take any sick leave at all. This is consistent with other studies, which had found no increase in sickness absenteeism among 12 hour shift workers when compared to eight hour shift workers.[9 10] A review found that if at all, sickness absenteeism decreased for the 12 hour shift system, although it was pointed out that since the 12 hour shift is combined with a compressed work week, this could be the result of an artefact of having fewer work days that a worker could be absent from.[9]

Disincentives such as the attendance allowance could also have a differential impact. If the wafer fabrication factories did not pay, or paid lower attendance allowances, this could have contributed to the higher proportions taking sick leave. However, this was not the case, as all three wafer fabrication factories paid an attendance allowance; although in one, it was only 1% of basic starting salary, in the other two, it ranged between 18.9% and 26.3% and between 17.9% and 24.4% of basic starting salary. In comparison, two of the 15 semiconductor assembly factories did not pay the allowance, and in the others that did, the range was between 7.3% and 13.3%, with an outlier of 28%.

The relation between work section and sick leave may reflect other managerial and work organisational factors that were not included in this study. One study among Swedish post workers, for example, found that a high sickness absence was related to features such as the occurrence of bullying at the workplace, workplace with more than 50 people, member of a work team, seldom or never able to discuss with supervisor, and social contacts by active participation in trade union work.[11] Other studies have found sickness absence to be significantly related to psychosocial factors such as lack of influence on own job situation,[12] low job satisfaction,[13] and low levels of decision latitude.[8] This study was also limited in its scope in that it did not include an investigation of the reasons for taking sick leave. Other studies have found the reasons for taking sick leave to include injury, physical illness, as well as mental health problems.[7 14–17]

CONCLUSION

This study has shown that within the semiconductor industry itself, wafer fabrication plants in Malaysia, although without the full range of work processes, already show higher sick leave rates for workers compared to semiconductor assembly plants. In light of governmental policy to encourage the setting up of wafer fabrication plants with the full range of work processes, it is therefore important that further investigation be conducted on the reasons for these higher rates. This study was limited in that it did not have access to clinic or company records on sick leave, nor was it designed to collect qualitative data from interviews or focus group discussions. Further research should explore these other data sources, as well as investigate workplace exposures through industrial hygiene measurements.

Enforcement agencies will need to ensure the stringent implementation of recent occupational health and safety legislation, such as requiring all factories using chemicals to undertake the chemical health risk assessment that is provided for under the Occupational Safety and Health (Use and Standards of Exposure of Chemical Hazardous to Health) Regulation (2000). Under these regulations, health surveillance, including annual medical examinations and biological monitoring, is required for workers who use chemicals that pose significant risks. Occupational health physicians are also required to inform the Department of Safety and Health of the medical surveillance that they conduct annually. A system of collecting routine information on illness will be the first step towards a simultaneous policy of encouraging the setting up of adequate occupational health and safety measures.

ACKNOWLEDGEMENTS

This research is funded under the Health and Lifestyle Research Programme by the Intensification of Research Priority Areas (IRPA, Medical Sector) Programme of the Malaysian Government, implemented through the Ministry of Science, Technology, and Environment (UPM Project Grant No: IRPA 06-02-05-7011). The Health and Lifestyle Programme was led by Dato' Professor Mustaffa Embong (until December 2000) and Professor Mafauzy Mohamed (from January 2001), both of Universiti Sains Malaysia. The Department of Occupational Safety and Health provided strong support, without which this research project would never have taken place. Thanks are extended to Associate Professor Dr Khadijah Shamsuddin for her insightful comments, and to Ng Wei Khiang and C Abherhame for their assistance in data collection and analysis.

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REFERENCES

1 **LaDou J**. Health issues in the microelectronics industry. *State of the Art Reviews, Occupational Medicine: The Microelectronics Industry* 1986;**1**:1–11.
2 **LaDou J**, Rohm T. The international electronics industry. *Int J Occup Environ Health* 1998;**4**:1–18.
3 **Balcazar H**, Denman C, Lara F. Factors associated with work-related accidents and sickness among Maquiladora workers: the case of Nogales, Sonora, Mexico. *Int J Health Serv* 1995;**25**:489–502.
4 **Guendelman S**. The health consequences of Maquiladora work: women on the US-Mexican border. *Am J Public Health* 1993;**83**:37–44.
5 **Lin V**. *Health, women's work, and industrialization: semiconductor workers in Singapore and Malaysia*. New York and London: Garland Publishing, Inc., 1991.
6 **Malaysia**. *Eighth Malaysia Plan, 2001–2005*. Kuala Lumpur: Government Printers.
7 **Brenner H**, Ahern W. Sickness absence and early retirement on health grounds in the construction industry in Ireland. *Occup Environ Med* 2000;**57**:615–20.
8 **Niedhammer I**, Bugel I, Goldberg M, *et al*. Psychosocial factors at work and sickness absence in the Gazel cohort: a prospective study. *Occup Environ Med* 1998;**55**:735–41.
9 **Smith L**, Folkard S, Tucker P, *et al*. Work shift duration: a review comparing eight hour and 12 hour shift systems. *Occup Environ Med* 1998;**55**:217–29.
10 **Chan OY**, Gan SL, Yeo MH. Study on the health of female electronics workers on 12 hour shifts. *Occup Med* 1993;**43**:143–8.
11 **Vossa BM**, Floderusa BB, Diderichsenc F. Physical, psychosocial, and organisational factors relative to sickness absence: a study based on Sweden Post. *Occup Environ Med* 2001;**58**:178–84.

12 **Eshoj P**, Jepsen JR, Nielsen CV. Long-term sickness absence—risk indicators among occupationally active residents of a Danish county. *Occup Environ Med* 2001;**51**:347–53.
13 **Hoogendoorn WE**, Bongers PM, de Vet HCW, *et al*. High physical work load and low job satisfaction increase the risk of sickness absence due to low back pain: results of a prospective cohort study. *Occup Environ Med* 2002;**59**:323–8.
14 **Wright ME**. Long-term sickness absence in an NHS teaching hospital. *Occup Med* 1997;**47**:401–6.
15 **Verow P**, Hargreaves C. Healthy workplace indicators: costing reasons for sickness absence within the UK National Health Service. *Occup Med* 2000;**50**:251–7.
16 **Feeney A**, North F, Head J, *et al*. Socioeconomic and sex differentials in reason for sickness absence from the Whitehall II Study. *Occup Environ Med* 1998;**55**:91–8.
17 **Ritchie KA**, Macdonald EB, Gilmour WH, *et al*. Analysis of sickness absence among employees of four NHS trusts. *Occup Environ Med* 1999;**56**:702–8.

Answers to multiple choice questions on *Hydrogen sulfide: UK occupational exposure limits* by MG Costigan, on pages 308–312

(1) (a) false: olfactory fatigue develops at high concentrations; (b) false: gas eye only appears to occur with H_2S exposures in the region of hundreds of ppm; (c) true; (d) false; H_2S is rapidly metabolised and eliminated from the body
(2) (a) false; (b) true; (c) true; (d) true
(3) (a) false; (b) false; (c) true; (d) false
(4) (a) false; (b) false; (c) true; (d) true
(5) (a) true; (b) false; (c) false: a NOAEL of 30 ppm was identified in rats and mice; (d) false: although human evidence was of central importance to the derivation of the OESs for H_2S, the animal evidence was also taken into account—the STEL OES of 10 ppm was judged to provide an adequate margin of safety compared to the animal NOAEL of 30 ppm