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Urinary Tract Infection among Clean-Room Workers

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Abstract: Urinary Tract Infection among Clean-Room Workers: Jian Nan WANG[1], *et al.*[1] Department of Family Medicine, Chie-Mei Foundation Hospital—Many high-tech industries do some manufacturing processes in clean-rooms to ensure high quality and yield. To prevent contamination, workers need to put on special clothing and go through certain cleaning procedures before entry. Therefore, some workers may limit their water intake and try not to go the bathroom, which are both risk factors of urinary tract infection (UTI). To assess the prevalence and risk factors of UTI among the workers, we conducted a study in an industrial park. We recruited workers who came to the clinic in the park for an annual health examination between September 1 and December 31, 2000. From each participant we collected a urine sample and obtained related information through a questionnaire. All the 1,054 qualified workers, including 416 men and 638 women, participated, and 693 (65.7%) were clean-room workers. Most clean-room workers were women (71.3%), and they tended to be younger and had lower frequencies of drinking water and going to the bathroom during the shift. A higher prevalence of UTI (6.2% vs. 2.5%, p = 0.008) was observed among clean-room workers. After adjusting for age, frequency of dinking water, and working in clean-rooms, female gender was a significant risk factor (odds ratio [OR] = 18.3, 95% confidence interval [CI]: 4.1 to 82.1) and going to the bathroom three times or more during a shift was a protective factor (OR = 0.3, 95% CI: 0.1 to 1.0). In conclusion, UTI is prevalent among clean-room workers, and frequent voiding is recommended for prevention of the disease.
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Key words: Urinary tract infections, Controlled environment, Occupational health, Industry, Working women

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To ensure high quality and high yield, many high-tech industries do some manufacturing processes in so-called "clean-room" conditions. In clean-rooms, the dust particles in the air were controlled to extremely low levels, and the temperature and the humidity are maintained at relatively low levels. To prevent contamination by dust, workers in clean-rooms have to put on special clothing covering the whole body from head to toe. They also need to go through certain cleaning procedures before entry. To keep production running 24 h a day, many factories have the workers work 12 h a day for two consecutive days and then rest for two days. During the day shift, they have a 20-min break in the morning, a lunch break for 50 min, another 20-min break in the afternoon, and a dinner break for 50 min. The intervals and lengths of breaks are the same for the evening shift. Because it takes time to change the clothing and go through the cleaning procedures, most workers need about 10 min to go out (such as for drinking water or going to the bathroom) and come back into the clean-room. As a result, some workers may limit their water intake and try not to go to the bathroom, but both are risk factors of urinary tract infection (UTI)[1–4].

High-tech industries such as semiconductor industries are usually considered as "clean" industries, but there are in fact many potential occupational hazards. One report indicated that the morbidity of occupational diseases in California semiconductor industries was three times that in other manufacturing industries (1.3% *vs.* 0.4%) and that the incidence of occupational injuries was also higher (4.1% *vs.* 3.2%)[5]. In a health survey on more than 30,000 workers from 48 semiconductor factories in Taiwan, abnormal findings were observed in 1.9% of male workers and 1.4 % of female workers[6]. The health hazards found in the production of semiconductor processes include organic solvents, toxic gases, acidic solutions, unusual odors, and ergonomic factors[7], but few

studies, if any, have been conducted on the prevalence of UTI among clean-room workers. To evaluate whether clean-room workers have a higher risk of developing UTI, we conduct a study in an industrial park.

Materials and Methods

We recruited workers in semiconductor factories located in the Tainan Science-Based Industrial Park who received an annual routine health examination between September 1 and December 31, 2000. During this period, a total of 1,054 workers from two factories received the health examination at the clinic in the park. Participants were asked to fill out a standard questionnaire, which included demographic data, frequency of water intake and voiding during a typical workday (shift), work history, diseases of the urinary tract system (trauma, remote infections, or stones), and clinical symptoms of UTI.

As a part of the routine health examination, a midstream freshly voided urine sample was collected and sent to the laboratory as soon as possible for dipstick tests (nitrite, leukocyte esterase, protein, occult blood, pH, specific gravity, *etc*.). We obtained permission from the participant to conduct more detailed analyses of the urine sample, including specimen appearance and microscopic examination of the centrifuged urinary sediment (for white blood cells [WBCs], red blood cells, bacteria, and abnormalities). The health examination also included a physical examination. The diagnosis of UTI was made on the basis of laboratory data, answers to the questionnaire, and the physical examination. The diagnostic criteria included the following:

1. The patient had clinical symptoms or signs of UTI, and urinalysis revealed more than 10 WBCs per high power field (pyuria) or bacteria (bacteriuria).
2. The patient was asymptomatic, but the urinalysis showed pyuria and bacteriuria.
3. The patient was under treatment for UTI.

We compared the prevalence of UTI and other characteristics in those who worked regularly in clean-rooms (clean-room workers) and those who did not (non-clean-room workers). The differences between the two groups were evaluated by chi-square or Fisher's exact test. Potential predictors of UTI were evaluated by univariate and then multivariate logistic regressions. The statistical analyses were conducted with the SAS package, and all statistical tests were performed at the two-tailed significance level of 0.05.

Results

All the 1,054 workers, 638 women and 416 men, agreed to participate. Among them, 494 women and 199 men were clean-room workers, and 144 women and 217 men were non-clean-room workers (Table 1). Clean-room workers included more women (71.3 % *vs*. 39.9%, $p < 0.001$) and had a younger age distribution–about a half of them (49.4%) were 24 yr old or younger. Fewer clean-room workers drank water three times or more during a shift (45.5% *vs*. 64.0%, $p < 0.001$), and fewer of them went to the bathroom three times or more during a shift (56.0% *vs*. 66.2%, $p = 0.001$). The prevalence of UTI was higher among clean-room workers (6.2% *vs*. 2.5%, $p= 0.008$).

A total of 52 cases of UTI were identified, and 50 were in women (Table 2). None of them had a history of urinary stones or trauma to the uro-genital tract, and none of the women were pregnant or in the menstrual period

Table 1. Comparison of clean-room and non-clean-room workers

Characteristic	Clean-room Worker		Non-clean-room Worker		*p*
	Number	(%)	Number	(%)	
Women	494	(71.3)	144	(39.9)	< 0.001
Age (yr)					< 0.001
< 20	70	(10.1)	5	(1.4)	
20–24	272	(39.3)	42	(11.6)	
25–29	207	(29.9)	129	(35.7)	
> 29	144	(20.8)	185	(51.3)	
Water intake during shift					< 0.001
0–1 time	131	(18.9)	86	(23.8)	
2 times	247	(35.6)	44	(12.2)	
3 times or more	315	(45.5)	231	(64.0)	
Urine voiding during shift					< 0.001
0–1 time	69	(10.0)	72	(19.9)	
2 times	236	(34.1)	50	(13.9)	
3 times or more	388	(56.0)	239	(66.2)	
Urinary tract infection	43	(6.2)	9	(2.5)	0.008

Table 2. Prevalence of urinary tract infection (UTI) by potential risk factors

Potential risk factor	With UTI	Without UTI	Prevalence (%)	*p*
Gender				< 0.001
Men	2	416	0.5	
Women	50	638	7.8	
Age (yr)				0.001
< 20	8	75	10.7	
20–24	24	314	7.6	
25–29	11	336	3.3	
> 29	9	329	2.7	
Water intake during shift				0.281
0–1 time	11	217	5.1	
2 times	19	291	6.5	
3 times or more	22	546	4.0	
Urine voiding during shift				0.346
0–1 time	8	141	5.7	
2 times	18	286	6.3	
3 times or more	26	627	4.2	

Table 3. Adjusted odds ratio of urinary tract infection associated with potential risk factors

Potential Risk Factor	Odds Ratio	[95% Confidence Interval]
Work environment		
Non-clean-room	1.0	
Clean-room	1.5	[0.7, 3.3]
Gender		
Men	1.0	
Women	18.2	[4.1, 82.1]
Age (yr)		
< 20	1.0	
20–24	0.7	[0.3, 1.7]
25–29	0.5	[0.1, 1.4]
> 29	0.9	[0.3, 2.8]
Water intake during shift		
0–1 time	1.0	
2 times	1.7	[0.6, 4.4]
3 times or more	1.5	[0.6, 4.2]
Urine voiding during shift		
0–1 time	1.0	
2 times	0.5	[0.2, 1.4]
3 times or more	0.3	[0.1, 1.0]

when the urine sample was taken. The prevalence of UTI decreased with age, but was lower in those who drank water three times or more or went to the bathroom three times or more during a work shift, although the differences were not statistically significant.

Uni-variate logistic regressions showed that working regularly in clean-rooms and female gender were significant risk factors for UTI, and that 25 yr of age or older was associated with a lower risk (Table 3). The multi-variate logistic regression showed that female gender was an independent risk factor of UIT (odds ratio [OR] = 18.3, 95% confidence interval [CI]: 4.1 to 82.1), whereas going to the bathroom three times or more during a shift was associated with a lower risk (OR = 0.3, 95% CI: 0.1 to 1.0).

Discussion

Because we conducted this study in conjunction with the routine health examination and used a questionnaire that only took about three min to fill out, we were able to achieve a 100% participation rate. The results showed that more women than men worked regularly in clean-rooms, which is compatible with our impression. Since clean-room workers generally work 12 h in a typical shift, it is not surprising that most of them were quite young. As expected, less clean-room workers drank water three times or more during a shift. Likewise, less clean-room workers went to the bathroom three times or more during the shift. During a typical 12-h shift, there are two 50-min meal breaks and two 20-min small breaks. Therefore, not too many clean-room workers were willing to take additional breaks for drinking water or going to the bathroom, and many of them even skipped the smaller breaks. The troublesome process of going in and out of the clean-room was one of the reasons.

The relatively high prevalence of UTI might still be an underestimation of the risk, because only those who had passed a three-month trial period were qualified for the routine health examination. Some of the clean-room workers who contracted UTI might leave the job before they reach the end of the trial period. Using "urinary tract infection," "urinary tract infections," "cystitis," "pyelonephritis," "clean-room," "controlled environments," "semi-conductor," "FAB," "high-tech industry," "occupational disease," "occupational diseases," "worker" and "occupation" as key words to search literature by Medline, we failed to find any article since 1966 on the prevalence of UTI in similar working populations, and therefore we were unable to make comparisons. The result of the literature search also indicated that this is an unrecognized problem.

Because no subject with UTI had a history of urinary stones or trauma to the uro-genital tract, or was pregnant or during the menstrual period when the urine sample was taken, these common risk factors for UTI could not become a confounder. In fact, most women in their menstrual periods will postpone their health check-ups, and most workers in the semiconductor industry were unmarried. Sexual behavior may also affect the risk of developing UTI[2, 4, 8], but the related information is hard to collect accurately, particularly from young Taiwanese women. On the other hand, more clean-room workers were under the usual age for marriage than non-clean-room workers, and whereas clean-room workers had to work evening shifts on a regular basis, most non-clean-room workers did not. Therefore, there was no obvious reason to believe that clean-room workers were more, if not less, sexually active than non-clean-room workers. And so, the higher prevalence of UTI in clean-room workers was not likely to be entirely attributable to differences in sexual activity.

Urinalysis is an essential part of the clinical diagnosis of UTI, and it may detect disease anywhere in the urinary tract. Although the definitive diagnosis of UTI is based on the urine culture which demonstrates heavy growth of pathological agents, it is impractical and not cost-effective in large studies on populations with a large proportion of normal participants. In fact, the proper use of urinalysis alone can achieve a sensitivity of 80% and a specificity of 83%[9]. In our study, each participant was asked to provide a freshly voided sample of midstream urine, and contamination during such a sampling procedure might affect the result. To obtain an accurate diagnosis, the best way to sample urine is to use catheterization or another sterile procedure, but they are not practical in large screening surveys. Actually, we did not make the diagnosis solely on the basis of the laboratory data. We took into consideration the reported symptoms of UTI (fever, chills, frequency, urgency, dysuria, flank pain, *etc*.) in the questionnaire and signs (knocking pain at the costovertebral angles, superpubic area tenderness, *etc*.) observed during the physical examination to improve the accuracy of the diagnosis. Furthermore, the same procedure was applied to both clean-room workers and non-clean-room workers, and the examiner was blinded to the exposure status (clean-room worker or non-clean-room worker) of the participants. Therefore, the effect of possible misclassification on the study results should be small.

Self-limitation of water intake is a common practice to avoid the need to go to the bathroom during the work shift and may increase the risk of developing UTI. In a study on UTI among 1,492 teachers with 791 (53%) responders, a half of the responders drank less while working to avoid the need to use the toilet, and those who drank less had a 2.21-fold higher risk of UTI[3]. In our study, we found that after adjusting for gender, age, working in the clean-room, and frequency of water intake during the shift, those who did not go to the bathroom during the shift had an OR for having UTI of 3.0 in comparison with those who went to the bathroom three times or more during the shift. After adjusting for gender, age and frequencies of water intake and urine voiding during the shift, the OR associated with working in the clean-room decreased from 2.5 (p = 0.008) to 1.5 and became not statistically significant (p = 0.346). Therefore, the high risk of UTI among clean-room workers was attributable, at least in part, to the facts that a large proportion of them were women and that they went to the bathroom less frequently.

With the improvement of modern techniques, more and more workers are working in highly artificial environments (controlled environments) to produce high-quality merchandise. In order to maintain the restricted environmental conditions and to stay in such an

environment for prolonged periods of time, workers usually need to wear personal protecting equipment including special clothing. In addition, many of them work 12 h a day for two consecutive days and then rest for two days to keep the production line running 24 h a day. During the shift, whereas there is often no restriction on the number of breaks, many of the workers are not willing to take extra breaks or even the regular breaks due to the troublesome procedures of going in and out of the controlled work environment. In this study, we found that clean-room workers had a higher prevalence of UTI and that frequent voiding during the shift was associated with a lower risk. As a result, the clean-room workers were advised not to limit the frequency of voiding during the shift. Nonetheless, this may just be one of many problems in the high-tech industry that are generally under-recognized. Further studies are needed to uncover the other problems and search for solutions.

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