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Reducing Urinary Tract Infections among Female Clean Room Workers

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ABSTRACT

***Objectives*: A higher prevalence of urinary tract infection (UTI) was observed among clean room workers than among others in our previous study in 2001. We implemented intervention programs for reducing UTI and evaluated their effects 2 years later.**

***Methods*: We conducted an intervention study in four factories in the industrial park where the previous study was conducted and recruited participants from women workers who received annual health examinations at the clinic of the park. The intervention included health education programs during the new employee orientation and seasonal on-the-job training. We also implemented other measures, including placing posters in the workplace and disseminating knowledge of UTI prevention through e-mail and oral communications. One-on-one education was provided to workers who were found to have UTI in the previous study.**

***Results*: All the 1666 qualified workers, including 1414 clean room workers and 252 nonclean room workers, agreed to participate. We found a similar prevalence (both 0.8%) of symptomatic UTIs (patients with clinical symptoms, such as voiding frequency, urgency, and burning sensation during voiding) in clean room and nonclean room workers. In the 366 participants who also participated in the previous study, we found a significant decrease in the prevalence of UTI (from 9.8% to 1.6%) and significant increases in the prevalence of water intake and urine voiding, three times or more during a shift ($p < 0.001$ for all McNemar tests).**

***Conclusions*: The interventions had achieved behavior modification and decreases in the prevalence of UTI.**

INTRODUCTION

Clinically, urinary tract infection (UTI) can be classified as asymptomatic UTI, lower UTI (acute cystitis), and upper UTI (acute pylonephritis).[1] UTI is more prevalent in women, and acute cystitis is the most common UTI in women. The urethra of a woman is much shorter than that in a man and has an opening that is very close to the vagina, which may facilitate ascending infection into the bladder by autoinoculation.[2,3] Although data on the prevalence of symptomatic UTI in Taiwan are limited, a study found the prevalence of bacteriuria in school girls (5–14 years old)

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to be 1%, and it increased to 4% in young adult women and then increased at a rate of 1%–2% for each 10-year increase in age thereafter.[4]

In high-tech electronic and optoelectronic industries, many manufacturing processes are placed in clean rooms to ensure high quality and high yield. In clean rooms, dust particles in the air are kept to extremely low levels, and the temperature and humidity are maintained at relatively low levels. To prevent contamination of dusts, workers in clean rooms have to wear special clothing that covers the whole body from head to toe. They also must go through certain cleaning procedures before entry. In addition, to keep the production running 24 hours a day, many factories have the workers work 12 hours a day for 2 consecutive days and then rest for 2 days. During the day shift, they have a 20-minute break in the morning, a lunch break for 50 minutes, another 20-minute break in the afternoon, and a dinner break for 50 minutes. The intervals and lengths of breaks are generally the same for the evening shift. Because it takes time to change clothing and go through the cleaning procedures, most workers need about 10 minutes to leave (such as for drinking water or using the bathroom) and go back into the clean room. As a result, even though there were no administrative controls of bathroom breaks, some workers adapted their behavior by limiting their water intake and trying not to go to the bathroom; thus, the female workers were more likely to acquire UTIs.

In a previous study in 2001 on clean room workers in the Tainan Science-Based Industrial Park, we found they had a higher prevalence of UTIs (6.2% vs. 2.5%, $p = 0.008$) and less water intake and voiding frequency during work in comparison with other workers.[2] A series of intensive and continuous intervention programs was implemented in the industrial park after the study. We conducted a study to follow up the behavior modification and changes in UTI prevalence after the intervention programs. Because a significant increased risk of UTI was observed only in women in the previous study, we focused the follow-up on woman workers.

MATERIALS AND METHODS

After the study in 2001, we implemented the following programs in the industrial park starting January 1, 2002:

1. Health education for all new employees. During new employee orientation, we discuss UTI prevention, including drinking water (>2000 mL for one work shift), frequent urine voiding, and not to refrain from going to the bathroom during the work shift. The content of the education program was developed on the basis of our previous report.[2]
2. Health education for all current employees. During seasonal training courses, we include a lecture, Prevention of Urinary Tract Infection in Women. The content of the lecture is similar to that given to new employees.
3. Health education targeted at workers who were found to have UTIs in the previous study. We provide one-on-one health education by occupational nurses or refer workers to clinics for further checkups and education. The content of this program is similar to that given to new employees.
4. Other health education measures. We place posters on the prevention of UTI and disseminate knowledge of strategies for UTI prevention through e-mail and oral communication.

To evaluate the effects of the intervention, we recruited women workers at optoelectronic factories in the Tainan Science-Based Park who received an annual routine health examination between August 1 and September 30, 2003. Participants who were pregnant, were menstruating, or had a history of urinary stones or trauma to the urogenital tract were excluded from the data analyses.

Participants were asked to complete a standard questionnaire, which included questions on demographic data, frequencies of water intake and voiding during a typical workday (shift), work history, past history of the urinary tract (trauma, remote infections, or stones), and clinical symptoms of UTI (voiding frequency, urgency, burning sensation during voiding) over the last 3 weeks. The questionnaire had been assessed for its reliability and validity before it was used in the previous study,[2] and the protocol of this study was approved by the Research and Ethical Review Board of the Chi-Mei Medical Center.

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) and other urine routine examination, which included specimen appearance and microscopic examination of the centrifuged urinary sediment for white blood cell (WBC) count, red blood cell (RBC) count, bacteria, and other abnormalities. All the dipstick tests were performed within 15 minutes after the urine was collected, and all the microscopic examinations were performed within 2 hours. The health examination also included a physical examination.

Diagnosis of UTI was made on the basis of laboratory data, answers to the questionnaire, and the physical examination. A participant was diagnosed as having UTI if she had clinical symptoms or signs of UTI and the urinalysis showed more than 10 WBCs per high power field (pyuria) or bacteria (bacteriuria) or if she was currently being treated for UTI.[5] The diagnosis was made in the same way as in our previous study in 2001.[2]

We compared the prevalence of UTI and other characteristics between those who were clean room workers and who were not (nonclean room workers) and evaluated the differences by chi-square or Fisher's exact test. We applied logistic regression to identify predictors of UTI and evaluate their effects. For those women who participated in both the previous and current studies, we compared the prevalence of UTI, water intake three times or more during a shift, and urine voiding three times or more during a shift before and after the intervention, using McNemar's test. We also performed conditional logistic regressions to evaluate the effects of water intake three times or more during a shift and urine voiding three times or more during a shift on the reduction of UTI. All statistical analyses were conducted using the SPSS 10.0 software package (Chicago, IL), and all statistical tests were performed at the two-tailed significance level of 0.05.

RESULTS

During the study period, 2495 woman workers from four factories received a health examination at the clinic for the industrial park, and all agreed to participate in the study. However, 829 participants were excluded from the analyses because of pregnancy, menstrual period, or history of uri-

TABLE 1. DEMOGRAPHIC CHARACTERISTICS OF STUDY POPULATION, 2003 ($n = 1666$)

Characteristics	*Clean room workers*	*Nonclean room workers*	p *value*
Marital status			
Unmarried	1146 (81.3%)	175 (69.5%)	<0.01[a]
Married	265 (18.7%)	77 (30.5%)	
Age, years			
<24	606 (42.6)%	33 (13.1%)	<0.01[a]
24–27	461 (32.6%)	81 (32.1%)	
28–30	191 (13.5%)	72 (28.6%)	
>30	156 (11.0%)	66 (26.2%)	
Employment duration, years			
0–2	435 (37.1%)	56 (26.5%)	<0.01[a]
3–4	608 (51.9%)	100 (47.4%)	
≥5	129 (10.2%	55 (26.1%)	
Water intake during shift, number of times			
0–1	101 (7.1%)	17 (6.7%)	<0.01[a]
2	318 (22.5%)	24 (9.5%)	
≥3	992 (70.2%)	194 (83.8%)	
Urine voiding during a shift, number of times			
0–1	14 (1.0%)	11 (4.6%)	<0.01[a]
2	179 (12.7%)	13 (5.4%)	
≥3	1221 (86.4%)	217 (90.0%)	
Urinary tract infection			
No infection	1402 (99.2%)	250 (99.2%)	>0.99[a]
Infection	12 (0.8%)	2 (0.8%)	
Urine pH	5.84 ± 0.79	5.92 ± 0.83	0.12[b]

[a]Chi-square test.
[b]*t* Test.

nary stones or trauma to the urogenital tract. Among the remaining 1666 qualified participants, 1414 were clean room workers and 252 were non-clean room workers (Table 1).

In comparison with nonclean room workers, clean room workers were generally younger and had a shorter employment duration and a smaller proportion of married women (Table 1). The frequencies of water intake and voiding during a shift were different between the two groups of workers. Whereas clean room workers had a lower prevalence of water intake three times or more and a lower prevalence of urine voiding three times or more during a shift, they had a higher prevalence of water intake twice and a higher prevalence of urine voiding twice during a shift. Nonetheless, the two groups of workers had a similar prevalence of UTI (both 0.8%) and similar urine pH (5.92 vs. 5.84, $p = 0.12$).

Using univariate logistic regression, we found that urine voiding three times or more during a work shift was associated with a significantly lower risk for UTI (Table 2). Urine voiding twice and water intake twice and three times or more were also associated with a lower risk of UTI, but the odds ratios (OR) were not statistically significant. Because the number of cases of UTI was too small, we did not perform further multivariate regression analyses.

A decrease in the prevalence of symptomatic UTI (9.8% to 1.6%) was found among the 366 participants who were included in both the previous and the current studies (Table 3). The paired data showed that 34 of the 36 (94%) participants who were found to have UTI in the previous study did not have symptomatic UTI in the current study, and only 4 of the 330 (1%) who did not have UTI in the previous study were found to have symptomatic UTI in the current study ($p < 0.001$ for McNemar's test). In addition, we found the proportion of participants who voided urine three times or more during a shift increased from 12.8% to 39.6% and that of participants who had water intake three times or more during a shift also increased, from 27.6% to 51.1%. The paired data showed that 114 of the 145 (79%) participants who voided urine less than three times during a shift in the previous study increased their urine voiding to three times or more during a shift in the current study, whereas only 16 of the 221 (7%) who voided urine three times or more during a

TABLE 2. ODDS RATIO FOR UTI AND ASSOCIATED 95% CONFIDENCE INTERVAL (CI) OF POTENTIAL RISK FACTORS

Characteristics	*Normal*	*UTI*	*OR (95% CI)*
Marital status			
Unmarried	1152 (79.6%)	12 (85.7%)	1
Married	295 (20.4%)	2 (14.3%)	0.65 (0.15–2.92)
Age, years			
<24	551 (38.0%)	5 (35.7%)	1
24–27	482 (33.2%)	2 (14.3%)	0.46 (0.09–2.37)
28–30	226 (15.6%)	5 (35.7%)	2.44 (0.70–8.50)
>30	191 (13.2%)	2 (14.3%)	1.15 (0.22–6.00)
Working area			
Nonclean room	219 (15.1%)	2 (14.3%)	1
Clean room	1231 (84.9%)	12 (85.7%)	1.07 (0.24–4.80)
Employment duration, years			
0–2	420 (34.9%)	4 (50.0%)	1
3–4	621 (51.7%)	2 (25.0%)	0.34 (0.06–1.86)
≥5	161 (13.4%	2 (25.0%)	1.30 (0.24–7.19)
Water intake during a shift, number of times			
0–1	104 (7.3%)	2 (14.3%)	1
2	305 (21.3%)	4 (28.6%)	0.68 (0.12–3.78)
≥3	1022 (71.4%)	8 (57.1%)	0.41 (0.09–1.94)
Urine voiding during a shift, number of times			
0–1	18 (1.2%)	2 (14.3%)	1
2	167 (11.6%)	2 (14.3%)	0.11 (0.01–0.81)
≥3	1256 (87.2%)	10 (71.4%)	0.07 (0.02–0.35)
Urine pH	5.87 ± 0.80	5.77 ± 0.61	1.14 (0.58–2.25)

TABLE 3. CHANGE IN PREVALENCE OF UTI AND RELATED HEALTH BEHAVIOR AMONG WOMAN WORKERS FROM 2001 TO 2004 ($n = 366$)

		After intervention			p[a]
		Urinary tract infections			
		UTI	non-UTI	Total	<0.001
	UTI	2 (5.6%)	34 (94.4%)	36	
	Non-UTI	4 (1.2%)	326 (98.8%)	330	
		Urine voiding during a shift			
Before intervention		<3 times	≥3 times	Total	<0.001
	<3 times	31 (21.4%)	114 (79.6%)	145	
	≥3 times	16 (7.2%)	205 (92.8%)	221	
		Water intake during a shift			
		<3 times	≥3 times	Total	<0.001
	<3 times	76 (40.6%)	111 (59.4%)	187	
	≥3 times	25 (14.0%)	154 (86.0%)	179	

[a]McNemar's test.

shift in the previous study decreased their urine voiding to less than three times during a shift in the current study ($p < 0.001$). Of the 187 (63%) participants who had water intake less than three times during a shift in the previous study, 111 increased their water intake to three times or more during a shift in the current study, and only 25 of the 179 (14%) who had water intake three times or more during a shift in the previous study decreased their water intake to less than three times during a shift in the current study ($p < 0.001$). Therefore, these workers had achieved effective health behavior modification.

Using conditional logistic regression, we found urine voiding three times or more during a shift was an independent protective factor of symptomatic UTI after adjusting for water intake to three times or more during a shift, which had an adjusted OR of 0.12 and a 95% CI of 0.01–0.99. Although water intake three times or more during a shift was also a protective factor of symptomatic UTI after adjusting for urine voiding three times or more during a shift, the effect was not statistically significant (adjusted OR = 0.48, 95% CI 0.08 = 2.66).

DISCUSSION

Our previous study in 2001 found a 2.5-fold higher prevalence of UTI among clean room workers in comparison with nonclean room workers, but the difference was no longer significant after adjusting for gender, age, and frequencies of water intake and urine voiding at work.[2] Urine voiding three times or more during a shift had an independent negative association with UTI.[2] However, that study was a cross-sectional study and, thus, cannot provide strong evidence for causal inference. The current study is an intervention study, which provides stronger evidence for causal inference than a nonexperimental study in general, and confirmed that urine voiding three times or more during a shift is an independent protective factor against UTI. During a typical 12-hour shift, there are two 50-minute meal breaks and two 20-minute short breaks. However, not 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 entering and leaving the clean room was the main reason.

Although we found increased risk of UTI among clean room workers in the previous study, the intervention was not limited to clean room workers. As a result, the prevalence of symptomatic UTI in nonclean room workers also decreased from 2.5% to 0.8%. Therefore, the effects of the intervention were not limited to the clean room workers and can be applied to other workers as well.

Because we have excluded participants who had a history of urinary stones or trauma to the urogenital tract and those who were pregnant or menstruating when the urine sample was taken, the potential confounding effects of these common risk factors of UTI were minimized in the analyses of data presented in Tables 1 and 2. In fact, most women will postpone their health checkups during their menstrual periods, and most workers in the semiconductor industry were unmarried. Sexual behavior may also affect the risk of developing UTI,[6–8] but related information is hard to collect accurately, particularly from young Taiwanese women. In the analyses of data on the 366 participants who were included in both the previous and the current studies, potential confounding effects were further controlled by comparing the participants themselves before and after the intervention.

Urinalysis is an essential part of the clinical diagnosis of UTI. Although the definitive diagnosis of UTI should be based on the urine culture, which demonstrates heavy growth of pathological agents, it is impractical and not cost-effective in 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%.[9,10] 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 of urine sampling is to use catheterization or other sterile procedures, but again, they are not practical in large screening surveys. In the current study, we did not make the diagnosis solely on the basis of the laboratory data; we also took into consideration reported symptoms of UTI (fever, chills, frequency, urgency, dysuria, flank pain) in the questionnaire and signs (knocking pain at costovertebral angles, suprapubic area tenderness) observed during the physical examination to improve the accuracy of the diagnosis. Furthermore, the same procedure was applied to both clean room workers and nonclean room workers, and the examiner was blinded to the exposure status (clean room worker or nonclean room worker) of the participants. Therefore, the effect on the study results of the possible misclassification should be small.

Drinking less or infrequently is a common practice to avoid the need of urinating during work shift and may increase the risk of developing UTI. In a study on UTI among 1492 teachers with 791 (53%) responders, half of the responders drank less while working to avoid the need of using the toilet, and those who drank less had a 2.21-fold higher risk of UTI.[11] In our previous study, the prevalence of water intake three times or more during a shift was lower in the clean room workers, but its negative association with UTI was not significant after adjusting for gender, age, working in the clean room, and frequency of water intake during the shift.[2] In the current study, whereas water intake three times or more during a shift appeared to be a protective factor against UTI, the effect was not statistically significant. Therefore, even though both frequent water intake and frequent urine voiding were reported to be protecting factors against UTI, our previous and current studies showed that the effect of frequent urine voiding was more prominent than that of frequent water intake. Because the number of cases of UTI was too small, we were not able to beak down the participants further. A larger study is needed to assess the dose-response relationship between the number of voidings and the occurrence of UTI.

The self-report approach adopted in our study to collect data of voiding and water intake may be as accurate as using a diary or direct observation, but it is much more feasible in a large-scale study. Keeping a diary requires good compliance to obtain accurate data, and it is hard to achieve in a study lasting for 1 year. Direct observation requires a great deal of manpower and may not be acceptable to the participants because of privacy issues. In particular, because we applied the same approach before and after the intervention, our observations on the effects of intervention are not likely to be affected.

Our study showed that health education programs in the workplace are effective in modifying certain behaviors of the workers, and the behavior modification reduced the recurrence of UTI. Studies in other settings have also demonstrated that a continuous and comprehensive educational session that addressed UTI, its risk factors, and behavioral changes might reduce its recurrence.[12,13] Therefore, the approaches applied in our study should have a wide application. Nonetheless, there are still some participants in our study who did not adopt the beneficial behaviors, and a very small proportion even changed to less advantageous behavior in terms of prevention of UTI. Further studies should be conducted to identify factors affecting the behavior modification in order to improve compliance.

CONCLUSIONS

With the advancement of modern techniques, more and more women are working in highly artificial environments (controlled environments) to produce high-quality merchandises. In order to maintain the restricted environmental conditions and to stay in such environments for prolonged periods of time, workers usually need to wear personal protective equipment, including special clothing. In addition, many of them work 12 hours a day for 2 consecutive days and then rest for 2 days to keep the production running 24 hours 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 because of the troublesome procedures of going in and out of the controlled work environment. In this study, we found that intensive health education can change and improve the behavior of the workers and, more importantly, achieve a reduction in prevalence of UTI. Therefore, we conclude that health education and behavior modification, particularly more urine voiding during the work shift, are simple and effective ways to reduce UTI among women workers.

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