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Prevalence of Musculoskeletal Disorder among Workers in Taiwan: A Nationwide Study

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Abstract: Prevalence of Musculoskeletal Disorder among Workers in Taiwan: A Nationwide Study: How-Ran Guo, *et al.* Department of Environmental and Occupational Health, Medical College, National Cheng Kung University, Taiwan R.O.C— Musculoskeletal disorder (MSD) is a common problem among workers. In spite of the numerous reports on MSD in various specific groups of workers, few data on the prevalence in the general working population are available except for back pain. We analyzed the information collected through a nationwide survey in Taiwan in 1994 to estimate the prevalence of MSD by age, gender, and education level and identify high-risk industries. In the survey, a standard questionnaire was distributed to a representative sample of 22,475 non-self-employed workers in Taiwan. National estimates were obtained by applying a weight to each participant. Among the sampled workers, 18,942 (84.3%) participated, and 37.0% (standard error=0.4%) had MSD. Female workers had a significantly higher overall prevalence than male workers (39.5% vs. 35.2%, $p<0.05$). Education and age also had significant associations with MSD ($p<0.001$ in both genders). "Lower back and waist" were the most frequently affected body parts (18.3% among males and 19.7% among females), but the prevalence of MSDs of the neck, shoulders, hands and wrists were also above 10%. The top ten high-risk major industries for MSD of various body parts for each gender were identified, and some industries, including "Basic Metal Industries" and "Buildings Construction," were among the top ten for multiple body parts. Our study showed that MSDs of body parts other than the back are also prevalent, especially in the neck, shoulders, hands and wrists. We also identified high-risk industries for further research and intervention.
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Key words: Musculoskeletal disorder, Back pain, Neck pain, Shoulder pain, Metal industry, Construction, Epidemiology

Musculoskeletal disorder (MSD) is a common health problem in the working population. In the United States, for example, about one fourth of workers' compensation claims are filed for back pain[1, 2], and about one third of workers' compensation costs are paid to back pain claims[3, 4]. The total cost of back pain was about $50 to $100 billion in 1990[5], and about 22.4 million workers had suffered from back pain everyday for a week or more in 1988[6]. Back pain is the second most common reason for sick absence from work[4] and ranks as the fifth most common reason for physician office visits[7]. In Taiwan, whereas the data on the working population were limited, the National Health Insurance Bureau found that more than 2.14 million patients sought medical care for back pain in 1998 and that the medical cost alone exceeded 3 billion New Taiwan Dollars (about 100 million U.S. Dollars)[8]. Back pain is a major occupational health problem in many other countries as well[7–17]. In spite of the numerous papers published on MSD of different body parts in various groups of workers[18], very few large-scale surveys on MSD of body parts other than the back have been reported. Therefore, even the most basic statistics such as prevalence in the general working population are very limited.

The Institute for Occupational Safety and Health (IOSH), a national governmental research agency in Taiwan, conducted the Survey of Employees' Perceptions of Safety and Health in the Work Environment in 1994, which was a nationwide personal interview questionnaire

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survey on a representative sample of employees in all kinds of industry in Taiwan. The goal of this survey was to collect information on the physical, chemical and ergonomic health hazards in the work environment as well as employees' perceptions of the safety and hygiene in their work places. In addition, the questionnaire included questions on the occupational health education programs and health examinations received by the employees and their health problems, including MSD of various body parts[19]. This survey provided a unique opportunity to study the epidemiology of MSD in the working population in general. We analyzed the data collected by the survey to estimate the prevalence of various MSDs by age, gender, and education level. In addition, we tried to identify high-risk industries for planning further research and intervention programs.

Materials and Methods

The Survey of Employees' Perceptions of Safety and Health in the Work Environment was conducted by the IOSH in 1994 as a supplement to the Human Resources Survey organized by the Department of Statistics, who conduct large scaled nationwide surveys on a routine basis. A representative sample of workers employed in the week of September 17, 1994 was obtained by a two-stage sampling approach. In the first stage, "villages" and "lis" (a unit of administration region in urban areas, equivalent to "village" in rural areas) were stratified into 24 strata according to the level of urbanization. Among the 7,416 lis and villages in Taiwan, 515 were randomly selected for the second stage. The number of villages (lis) to be sampled from a specific stratum was determined according to the total number of villages (lis) in that stratum. The average number of households in a village (li) was 731. In the second stage, households were randomly sampled according to the list of the residents living in the village (li) during the month before the survey was conducted. Likewise, the number of households to be sampled from a specific village (li) was determined according to the total number of households in that village (li). Because random sampling was applied in both stages, the representativeness of the sample was ensured[19]. Furthermore, because the sampling fractions were known in both stages, the number of individuals represented by each sampled interviewee, which would be adopted as the weighting factor in the data analyses, can be calculated precisely[19]. The household registration system in Taiwan is for census purpose, not for taxation. As the result, a total of 22,475 non-self-employed workers, including 13,365 men and 9,110 women, were identified among the 19,416 sampled households. All the adults in each sampled household were asked to participate in the survey. The same agencies had successfully conducted two similar surveys with a focus on health hazards in the work environment in 1988 and 1991 respectively[19].

To each sampled worker, a standard questionnaire was distributed directly by an interviewer hired by the IOSH. The worker was asked to fill out the questionnaire, which was collected by the interviewer right after completion. If the participant was not able to complete the questionnaire or had questions, the interviewer might offer help. The questionnaire was designed to be completed in 10 to 12 min in most cases. Upon receipt of the answered questionnaire, the interviewer performed an on-site error check to correct possible errors and clarify confusion. Before the survey, all the interviewers had received a series of standard training and been given a standard procedure manual. The door-to-door questionnaire administration was conducted at different times and on different days of the week to accommodate the availability of the interviewee. A telephone call was made beforehand whenever possible to make an appointment with the candidate for interview. In addition, multiple attempts were made to reach the interviewee to ensure a high response rate. Whereas no incentive was given for participation, the survey was conducted in conjunction with the Human Resources Survey organized by the Department of Statistics, who conduct large scaled nationwide surveys on a routine basis and had achieved high response rates in the past through experienced interviewers[19].

The questionnaire included questions on demographic characteristics; physical, chemical and ergonomic risk factors in the work environment; the worker's perceptions of the safety and health in the work place; the occupational health education programs and health examinations received by the worker; and the health problems of the worker. Among the health problems, the question "In the past year at your job, did you have soreness or pain in any body part?" was used to ask participants to recall whether they had MSD characterized by pain or soreness during the one-year period before the interview. Those who recalled having MSD were then asked to check the involvement of each of the following nine body parts: neck, upper back, lower back and waist, shoulder, elbow, hand and wrist, hip and thigh, knee, and ankle. An illustration of the human body was printed on the questionnaire to indicate the body parts. The industry of each participant was coded according to the Standard Industrial Classification System of the Republic of China (SICSROC)[20]. In our analyses, an "industry" refers to an industry with a specific two-digit code. Although most of the industries can be further divided into smaller industries with three-digit codes, the survey used the two-digit coding system. To facilitate comparison with data from other countries, we also re-code the industries according to the three-digit coding system made by the U.S. Bureau of Census (BOC)[21].

Because the survey was conducted on a representative sample, we can generate national estimates by applying

Table 1. Estimated Number of Cases (in Thousands) and Prevalence of Musculoskeletal Disorder by Gender and Body Part

Body Part	Male			Female		
	Cases	Prevalence		Cases	Prevalence	
	[× 1000]	%	SE	[× 1000]	%	SE
Neck	372	11.9	0.4	320	14.7	0.5
Shoulder	451	14.4	0.4	379	17.4	0.5
Upper Back	136	4.4	0.2	117	5.4	0.3
Lower Back and Waist	574	18.3	0.4	428	19.7	0.5
Elbow	183	5.6	0.3	109	5.0	0.3
Hand and Wrist	335	10.7	0.4	224	10.3	0.4
Hip and Thigh	111	3.5	0.2	101	4.6	0.3
Knee	115	3.7	0.2	80	3.7	0.2
Ankle	100	3.2	0.2	79	3.6	0.3
Any Body Part	1016	35.2	0.5	860	39.5	0.6

a weighting factor, which was the number of people being represented by each interviewee as determined in the sampling plan[19]. In addition to the Human Resources Survey in Taiwan, similar approaches have been applied in the National Health Interview Survey by the U.S. government to obtain national estimates for decades[6]. In reporting the projected numbers of cases, we rounded off the figures to increments of 1000. The data were analyzed with the Software for Survey Data Analyses (SUDAAN), which was designed for analysis of data from complex multistage surveys[22]. Since some industries had limited numbers of employees and therefore the numbers of participants were small, some of the analyses were conducted only on "major industries," defined as an industry that constituted more than 0.5% of the workers of a given gender. Among the 76 industries with specific two-digit codes, 44 were identified as major industries for each gender, and 39 were major industries for both genders. Of the 18,942 participants, 796 were not employed in major industries. For each condition, we calculated the estimated total number (in thousands) of cases and prevalence in each gender. Differences in prevalence were evaluated by chi-square tests at the two-tailed significant level of 0.05. In addition, the relative risk was approximated by the prevalence ratio as compared to all male or female workers.

Results

Over-All Prevalence and Prevalence by Body Part

A total of 18,942 candidates (participating rate=84.3%), including 11,336 (participating rate=84.8%) representing about 3.1 million male workers and 7,606 (participating rate=83.5%) representing 2.2 million female workers, responded to the survey. The major reason for exclusion was failure to reach the candidate (85.3%), followed by refusal to participate (5.5%). Among the participants, 37.0% (standard error [SE] =0.4%) had MSD, projecting to about 1,016,000 male and 860,000 female cases (Table 1). For MSD of any of the nine body parts, the prevalence in female workers was significantly higher than that in male workers (39.5% vs. 35.2%, $p<0.001$ for chi-square test). Among the nine body parts, "lower back and waist" were the most frequently affected (18.3% among male workers and 19.7% among female workers), followed by "shoulder" (14.4% and 17.4% in male and female workers respectively). The prevalence of MSD of the "neck" or "hand and wrist" was also above 10% in both genders, but the prevalence of MSD of the other five body parts was much lower (Table 1).

Prevalence by Age and Education Groups

Age had a significant association with MSD ($p<0.001$ for chi-square test in both genders), and workers between 45 and 64 yr of age had the highest prevalence in both genders (Table 2). In general, effects of age were similar for different body parts, and the prevalence tended to increase with age (Figs. 1 and 2). The youngest age group (<18 yr), however, did not have the lowest prevalence for most conditions. The most common pattern was that the prevalence decreased from the first age group (<18 yr) to the second age group (18 to 24 yr), increased with age till 45 to 54 or 55 to 64 yr old, and then decreased again ($p<0.001$ for the chi-square test in both genders). This pattern was observed for "upper back" and "hand and wrist" in male workers; "upper back" and "hip and thigh" in female workers; and "neck," "elbow," "knee," and "ankle" in workers of both genders, but the initial decrease with age was not observed for "upper back" and "hip and thigh" in male workers and "lower back and waist" and "shoulder" in workers of both genders.

Table 2. Estimated Number of Cases (in Thousands) and Prevalence of Musculoskeletal Disorder of Any Body Part by Gender, Age, and Education

Variable	Male			Female		
	Cases	Prevalence		Cases	Prevalence	
	[× 1000]	%	SE	[× 1000]	%	SE
Age (yr)						
<18	15	29.0	3.6	13	33.5	4.4
18–24	86	24.8	1.4	141	27.8	1.2
25–34	358	31.8	0.8	297	38.6	1.1
35–44	357	38.0	0.9	263	45.0	1.2
45–54	187	43.1	1.4	113	52.6	1.8
55–64	91	44.0	1.8	32	52.5	3.6
>64	11	35.8	4.7	2	41.0	0.6
p value*		<0.001			<0.001	
Education						
None	13	24.2	3.9	7	35.5	7.9
Self–educated	12	50.6	5.7	27	62.1	4.4
Primary School	9	59.1	6.7	4	51.5	9.0
Junior High School	262	47.6	1.3	190	51.4	1.4
Senior High School	242	37.6	1.1	124	42.7	1.8
Professional School	98	33.4	1.7	62	34.7	2.0
Junior College	260	33.4	1.0	229	33.1	1.1
College	127	27.7	2.2	131	36.8	1.6
Graduate School	84	25.6	1.4	86	39.4	2.0
p value*		<0.001			<0.001	

**p* value for chi-square test for the difference across the groups

The final drop in prevalence was not observed for "lower back and waist" in male workers and "hand and wrist" in female workers (Figs. 1 and 2). The differences in the prevalence of various MSDs among different age groups were all statistically significant, except for MSDs of ankles among female workers.

Education also had a significant association with MSD ($p<0.001$ for chi-square test in both genders), but the patterns of association were different for the two genders. In male workers, the prevalence of MSD increased as the education level increased from "none" to "primary school," which had the highest prevalence (59.1%), and then decreased as the education level increased. In female workers, the prevalence of MSD increased as the education level increased from "none" to "self-educated," which had the highest prevalence (62.1%), and then increased as the education level decreased, but increased again after the level of junior college (Table 2).

High-Risk Industries

Among male workers, the major industry with the highest prevalence of MSD of all nine bodily parts combined was "Transport" (relative risk in terms of prevalence ratio as compared to all male workers=1.4), whereas "Building Construction" had the largest estimated number of cases (171,000) (Table 3). According to SICSROC, "Transport" as identified by the two-digit codes 61 consists of four three-digit industries ("Land Transport," "Water Transport," "Air Transport," and "Transport Services"), which corresponds to industries with three-digit BOC[21] codes 400, 401, 402, 410, 420, and 421. "Building Construction" (two-digit SICSROC code 46) is a very homogenous industry covering only one three-digit industry (460; "Building Construction"), which covers a single four-digit industry (4600; "Building Construction"), and corresponds to industries with the three-digit BOC code 060. The top ten industries with the highest prevalence accounted for 41.2% of male cases. Among female workers, the major industry with the highest prevalence of MSD of all nine bodily parts combined was "Wood and Bamboo Products Transport" (relative risk=1.5) (Table 3), whereas "Social and Related Community Services" had the largest estimated number of cases (133,000) (relative risk=1.0). "Wood and Bamboo Products" with the two-digit SICSROC code 16 consists of a single three-digit industry, which covers nine four-digit industries and corresponds to industries with BOC codes 231 and 241 as well as a

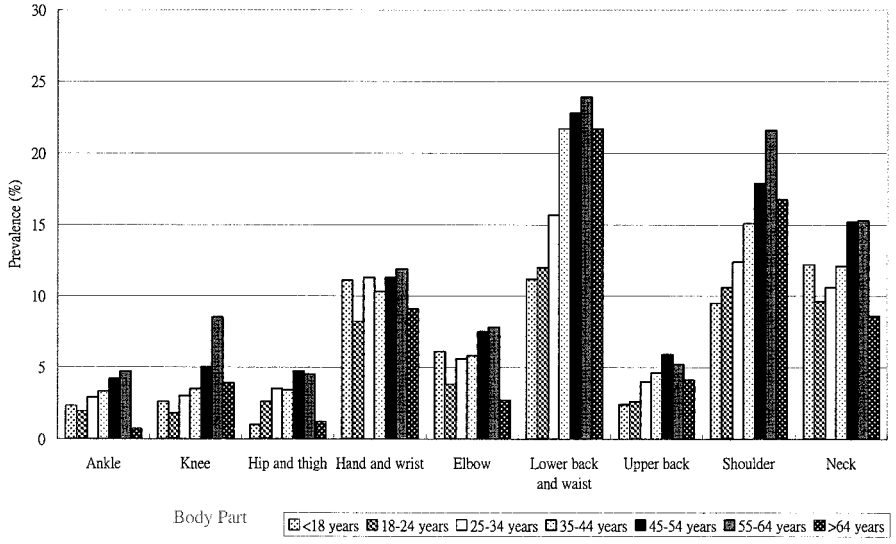

Fig. 1. Prevalence of musculoskeletal disorders among male workers by body part and age

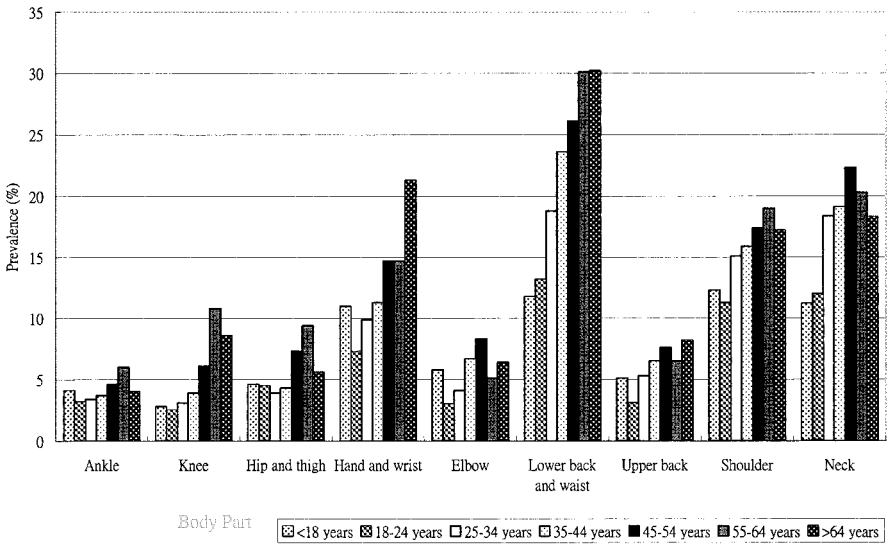

Fig. 2. Prevalence of musculoskeletal disorders among female workers by body part and age

part of those with 391. On the other hand, "Social and Related Community Services" (SICSROC code 82) covers six three-digit industries ("Education and Training Services," "Research and Service Institutes," "Medical and Health Services," "Social Welfare Services," "Civil Associations," and "Other Social and Related Community Services") and corresponds to industries with BOC codes 812, 820, 821, 822, 830, 831, 832, 840, 842, 850, 851, 852, 860, 861, 862, 871, 872, 880, 881 and 891. The top ten industries with the highest prevalence accounted for 17.4% of female cases.

The top ten major industries with the highest prevalence of MSD of various body parts for each gender are listed in Table 3. Quite a few industries were ranked among the top ten for more than one body part (Table 4). In particular, "Basic Metal Industries" (SICSROC code 27) was ranked among the top ten for all nine body parts of male workers and consists of four three-digit industries ("Iron and Steel Basic Industries," "Aluminum Basic Industries," "Copper Basic Industries," and "Other non-ferrous Metal Basic Industries"). These industries smelt, refine, treat, cast and perform secondary processing of metals and correspond to industries with BOC codes 270, 271, 272, 280, 281, 282, 290, 291, and 300. "Buildings

Table 3. The Top Ten Industries with the Highest Prevalence of Musculoskeletal Disorder of Each Body Part

Male				Female			
Industry	Case [× 1000]	Prevalence [%]	(SE)	Industry	Case [× 1000]	Prevalence [%]	(SE)
Any body part							
Transport	84	47.5	(2.1)	Wood and Bamboo Products	7	59.2	(7.5)
Building Construction	171	46.6	(1.5)	Sanitary and Pollution Controlling Services	7	58.5	(8.4)
Infrastructure Construction	24	46.1	(4.0)	Building Construction	36	54.2	(3.5)
Painting, Coating, Mounting and Matting	43	46.0	(3.5)	Agriculture, Animal Husbandry and Hunting	8	52.6	(7.4)
Furniture and Fixture Manufacturing	14	45.4	(5.3)	Pulp, Paper and Paper Product Manufacturing	7	52.5	(7.1)
Basic Metal Industries	19	41.6	(4.3)	Wearing Apparel and Accessory Manufacturing	50	50.3	(2.6)
Leather and Fur Product Manufacturing	7	41.4	(7.1)	Transport Equipment Manufacturing and Repairing	11	48.6	(6.3)
Sanitary and Pollution Controlling Services	12	41.0	(5.2)	Leather and Fur Product Manufacturing	9	47.0	(6.5)
Fabricated Metal Product Manufacturing	69	40.5	(2.1)	Publishing	7	44.0	(7.8)
Pulp, Paper and Paper Product Manufacturing	13	40.4	(4.8)	Rubber Product Manufacturing	9	43.9	(6.4)
Neck							
Electric Power Supply	5	23.0	(5.0)	Communication	4	23.7	(6.0)
Transport	34	19.5	(1.6)	Publishing	3	21.9	(6.3)
Painting, Coating, Mounting and Matting	17	17.8	(2.5)	Rubber Product Manufacturing	4	21.0	(7.0)
Transport Equipment Manufacturing and Repairing	10	14.9	(2.6)	Wood and Bamboo Products	2	20.4	(7.0)
Infrastructure Construction	8	14.3	(3.0)	Wearing Apparel and Accessory Manufacturing	20	20.3	(2.3)
Basic Metal Industries	6	13.8	(2.8)	Foreign Trade	15	19.4	(3.2)
Sanitary and Pollution Controlling Services	4	13.8	(3.8)	Electrical & Electronic Machinery Manufacturing and Repairing	42	18.9	(1.7)
Building Construction	51	13.8	(1.1)	Financing	11	17.9	(2.9)
Fabricated Metal Product Manufacturing	23	13.6	(1.6)	Construction	12	17.8	(2.6)
Personal Services	12	13.0	(2.2)	Transport	9	17.6	(3.0)
Shoulder							
Transport	41	22.8	(1.8)	Communication	5	30.0	(6.3)
Pulp, Paper and Paper Product Manufacturing	7	21.4	(3.8)	Transport Equipment Manufacturing and Repairing	6	29.3	(5.8)
Transport Equipment Manufacturing and Repairing	14	20.9	(2.9)	Publishing	5	28.7	(7.1)
Building Construction	75	20.5	(1.2)	Construction	18	27.3	(3.0)
Infrastructure Construction	11	19.9	(3.5)	Sanitary and Pollution Controlling Services	3	27.3	(8.0)
Sanitary and Pollution Controlling Services	6	19.5	(4.2)	Other Business Services	5	24.3	(6.0)
Furniture and Fixture Manufacturing	6	19.2	(4.4)	Foreign Trade	17	22.0	(3.1)
Basic Metal Industries	8	18.5	(3.2)	Transport	11	21.4	(3.6)
Electric Power Supply	3	17.2	(4.5)	Wood and Bamboo Products	2	21.3	(5.9)
Painting, Coating, Mounting and Matting	15	16.4	(2.2)	Legal and Accounting Services	5	20.9	(5.3)
Upper back							
Basic Metal Industries	4	10.0	(2.4)	Sanitary and Pollution Controlling Services	1	11.4	(6.3)
Wood and Bamboo Products	1	7.6	(4.0)	Rubber Product Manufacturing	2	11.1	(4.3)
Sanitary and Pollution Controlling Services	2	7.6	(3.3)	Basic Metal Industries	1	10.4	(5.4)
Building Construction	24	6.7	(0.8)	Furniture and Fixture Manufacturing	1	10.1	(5.0)
Electric Power Supply	1	6.3	(2.6)	Construction	7	9.9	(2.0)
Transport	11	6.3	(1.0)	Food Manufacturing	5	9.5	(2.5)
Fabricated Metal Product Manufacturing	10	6.0	(1.1)	Miscellaneous Industrial Product Manufacturing	4	8.0	(2.2)
Infrastructure Construction	3	5.6	(1.7)	Pulp, Paper and Paper Product Manufacturing	1	7.8	(3.7)
Retail Trade	3	5.4	(2.2)	Financing	5	7.6	(1.9)
Pulp, Paper and Paper Product Manufacturing	2	5.2	(2.3)	Chemical Product Manufacturing	1	6.1	(4.3)

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Male				Female			
Industry	Case [× 1000]	Prevalence (SE) [%]		Industry	Case [× 1000]	Prevalence (SE) [%]	
Lower back and waist							
Infrastructure Construction	17	32.9	(3.9)	Agriculture, Animal Husbandry and Hunting	7	43.6	(6.8)
Transport	49	27.9	(2.0)	Wood and Bamboo Products	4	36.2	(7.9)
Leather and Fur Product Manufacturing	5	24.9	(5.8)	Construction	23	34.7	(3.3)
Painting, Coating, Mounting and Matting	23	24.1	(2.8)	Sanitary and Pollution Controlling Services	4	31.2	(8.6)
Furniture and Fixture Manufacturing	7	23.9	(4.5)	Pulp, Paper and Paper Product Manufacturing	4	28.6	(7.0)
Building Construction	85	23.3	(1.2)	Wearing Apparel and Accessory Manufacturing	26	25.9	(2.3)
Transport Equipment Manufacturing and Repairing	15	23.2	(2.8)	Publishing	4	25.2	(6.8)
Basic Metal Industries	10	23.1	(3.5)	Leather and Fur Product Manufacturing	5	24.9	(5.2)
Fishing	4	22.9	(4.7)	Foreign Trade	10	24.9	(3.3)
Sanitary and Pollution Controlling Services	7	22.5	(4.4)	Transport Equipment Manufacturing and Repairing	5	23.9	(5.0)
Elbow							
Wood and Bamboo Products	2	13.0	(4.5)	Construction	9	14.3	(2.4)
Painting, Coating, Mounting and Matting	12	12.6	(2.1)	Wood and Bamboo Products	1	13.0	(5.6)
Wholesale Trade II	4	11.9	(4.2)	Transport Equipment Manufacturing and Repairing	3	13.0	(3.8)
Basic Metal Industries	5	11.5	(2.8)	Pulp, Paper and Paper Product Manufacturing	2	11.9	(4.5)
Building Construction	39	10.5	(0.9)	Basic Metal Industries	1	10.3	(5.9)
Furniture and Fixture Manufacturing	3	9.4	(3.1)	Sanitary and Pollution Controlling Services	1	9.9	(5.7)
Leather and Fur Product Manufacturing	2	8.7	(3.9)	Machinery and Equipment Manufacturing and Repairing	2	8.3	(3.7)
Infrastructure Construction	4	8.1	(2.1)	Wholesale Trade II	1	8.0	(5.7)
Transport Equipment Manufacturing and Repairing	5	7.8	(1.8)	Communication	1	7.3	(3.9)
Wholesale Trade I	5	7.6	(2.1)	Fabricated Metal Product Manufacturing	4	7.3	(2.0)
Hand and wrist							
Leather and Fur Product Manufacturing	4	19.7	(6.2)	Wood and Bamboo Products	4	32.6	(7.1)
Building Construction	72	19.6	(1.2)	Sanitary and Pollution Controlling Services	3	21.7	(7.6)
Painting, Coating, Mounting and Matting	18	18.7	(2.4)	Construction	13	20.0	(2.6)
Infrastructure Construction	9	16.8	(2.7)	Publishing	3	19.5	(6.4)
Eating and Drinking Places	9	16.3	(2.9)	Leather and Fur Product Manufacturing	3	18.4	(4.8)
Sanitary and Pollution Controlling Services	5	15.7	(4.0)	Pulp, Paper and Paper Product Manufacturing	2	16.3	(5.2)
Furniture and Fixture Manufacturing	5	15.4	(3.6)	Transport Equipment Manufacturing and Repairing	3	14.6	(3.9)
Fabricated Metal Product Manufacturing	23	13.8	(1.6)	Non-metallic Mineral Product Manufacturing	4	14.6	(3.3)
Basic Metal Industries	6	13.7	(2.8)	Food Manufacturing	8	14.3	(3.0)
Personal Services	14	13.0	(2.0)	Communication	2	13.9	(5.4)
Thigh							
Transport	15	8.6	(1.3)	Other Business Services	2	9.9	(4.3)
Wholesale Trade I	4	7.4	(2.1)	Miscellaneous Retail Trade	5	9.7	(2.5)
Fishing	1	7.3	(2.8)	Entertainments	2	8.5	(3.4)
Basic Metal Industries	3	7.2	(2.1)	Personal Services	7	7.6	(1.5)
Wood and Bamboo Products	1	6.3	(3.8)	Textile Mill Products	5	7.4	(1.7)
Electric and Pipe Line Building Construction	5	5.4	(1.5)	Pulp, Paper and Paper Product Manufacturing	1	7.3	(3.7)
Fabricated Metal Product Manufacturing	9	5.0	(0.9)	Social and Related Community Services	23	6.9	(0.9)
Leather and Fur Products Manufacturing	1	4.9	(3.5)	Sanitary and Pollution Controlling Services	1	6.9	(5.1)
Retail Trade	2	4.9	(1.9)	Wood and Bamboo Products	1	6.8	(4.8)
Furniture and Fixture Manufacturing	2	4.3	(2.2)	Machinery and Equipment Manufacturing and Repairing	1	6.3	(3.7)

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(continued)	Male			Female			
	Industry	Case [× 1000]	Prevalence (SE) [%]	Industry	Case [× 1000]	Prevalence (SE) [%]	
Knee							
Agriculture, Animal Husbandry and Hunting	2	8.9	(3.6)	Miscellaneous Retail Trade	6	11.5	(2.9)
Basic Metal Industries	3	7.7	(2.3)	Wood and Bamboo Products	1	8.4	(4.8)
Printing Processing	2	7.6	(2.8)	Construction	5	7.0	(1.9)
Transport Equipment Manufacturing and Repairing	5	7.0	(1.6)	Chemical Matter Manufacturing	1	6.3	(4.5)
Transport	12	7.0	(1.1)	Textile Mill Products	4	5.8	(1.5)
Wood and Bamboo Products	2	6.7	(3.4)	Social and Related Community Services	19	5.6	(0.8)
Fishing	1	6.3	(2.2)	Publishing	1	5.4	(4.0)
Wearing Apparel and Accessory Manufacturing	1	5.7	(3.3)	Entertainment	1	5.3	(2.8)
Wholesale Trade II	2	5.6	(3.0)	Machinery and Equipment Manufacturing and Repairing	1	5.2	(3.4)
Wholesale Trade I	3	5.4	(1.8)	Personal Services	5	5.2	(1.5)
Ankle							
Transport	12	6.5	(1.1)	Miscellaneous Retail Trade	7	14.3	(3.2)
Basic Metal Industries	3	5.7	(2.0)	Wood and Bamboo Products	1	8.0	(5.4)
Fishing	1	4.9	(2.2)	Personal Services	7	7.6	(1.6)
Wholesale Trade II	1	4.7	(2.9)	Retail Trade	20	6.2	(1.7)
Social and Related Community Services	9	4.5	(0.9)	Social and Related Community Services	20	6.0	(0.8)
Wholesale Trade I	3	4.5	(1.5)	Textile Mill Products	4	5.5	(1.7)
Pulp, Paper and Paper Product Manufacturing	1	4.5	(1.8)	Machinery and Equipment Manufacturing and Repairing	1	5.2	(3.4)
Sanitary and Pollution Controlling Services	1	4.3	(2.3)	Precision Instrument Manufacturing	1	4.9	(3.8)
Wood and Bamboo Products	1	4.3	(2.9)	Miscellaneous Industrial Product Manufacturing	2	4.0	(1.9)
Plastic Product Manufacturing	3	4.2	(1.5)	Food Manufacturing	2	3.9	(1.4)

Table 4. Industries with High Prevalence of Musculoskeletal Disorder of Multiple Body Parts

Number of Body Parts with High Prevalence	Male	Female
9 (All Included)	Basic Metal Industries	—
8	—	Wood and Bamboo Products
7	Transport	Building Construction
6	Infrastructure Construction Building Construction Sanitary and Pollution Controlling Services	Sanitary and Pollution Controlling Services
5	Wood and Bamboo Products Furniture and Fixture Manufacturing Transportation Equipment Painting, Coating, Mounting and Matting	Pulp, Paper and Paper Product Manufacturing Publishing

Construction" was ranked among the top ten for six body parts of male workers and seven of female workers. "Sanitary and Pollution Controlling Services" (SICSROC code 81) was ranked among the top ten for six body parts of both genders and covers only one three-digit industry. It consists of seven four-digit industries ("General refuse System," "Enterprise Refuse System," "Human Excreta Collection and Disposal," "Cleaning Services for Houses

and Buildings," "Pathogen Controlling Services," "Environment Test Services," and "Other Sanitary and Pollution Controlling Services") and corresponds to industries with BOC codes 471 and 722.

Discussion

Over-All Prevalence and Prevalence by Body Part

The one-year prevalence of MSD of the lower back and waist observed in our study was higher than that of back pain observed among the workers in the National Health Interview Survey (NHIS) conducted in 1988 in the United States (18.9% vs. 17.6%)[6], but the NHIS included only persons suffering from at least one episode of back pain every day for a week or more, and therefore it is hard to compare the results directly. Besides the back, data from a large scale nationwide survey on MSD of other body parts are very limited. Our study demonstrated that MSD of some body parts was also prevalent in the working population in Taiwan. More than 10% of the workers had MSD of the neck, shoulders, or hands and wrists. A review of the insurance claims on occupational injuries filed from 1991 to 1996 in Norway found that the back, shoulders and arms, and head and face were the most frequently affected bodily parts, but the neck was ranked the eighth[23].

Although self-reporting is usually considered a less reliable way to measure disease outcome, MSD is a mainly self-reported condition. Even some false reporting would surely have occurred, there was no incentive or threat for interviewees to give false information because confidentiality was guaranteed. Therefore, the effect of misclassification should be minimal. On the other hand, application of other approaches, such as reviewing hospital records or performing physical examinations, may lead to more misclassifications, usually false negative than in using questionnaires[6]. Therefore, self-reporting should not be regarded as a weakness, if not a strength, of this study, and even though there are some limitations associated with self-reporting, they are the limitations to studying MSD in general.

Nationwide studies on MSDs other than back pain are very limited througout the world, but MSDs of the neck and the upper extremities have been recognized as important health problems in some countries. A study in the Netherlands estimated that the total cost of neck pain was around 686 million U.S. Dollars in 1996[24]. Although the related national statistics are limited, it was estimated that more than 2 billion U.S. Dollars in workers' compensation costs were spent annually on MSD of the upper extremities, and the U.S. National Institute for Occupational Safety and Health (NIOSH) listed MSD of the upper extremities among the National Occupational Research Agenda[25].

Gender differences in the prevalence of MSD are frequently observed, but the degree might differ from country to country. The 1988 NHIS in the U.S. reported a higher prevalence of back pain in male workers[6], and a study on lower back pain in Japan from 1986 to 1988 showed the incidence in male worker was about four times greater than that in female workers[26]; both are different from our observations. A study in Finland found that back pain was more common among women, but it was conducted on a representative sample of the general population, not on a working population exclusively[27].

While data from large surveys covering multiple body parts are limited, we speculate that the back might be the most frequently affected body part in other countries as well, judging from the literature on workers' compensation in the United States[1, 3].

Prevalence by Age and Education Group

The "dose-response" relationship between age and MSD was not linear, suggesting that multiple factors were involved (Figs. 1 and 2). Age by itself is a risk factor for MSD, and cumulative traumas, an important etiology of MSD, take time to develop[6, 11]. Therefore, there is a general trend to an increasing risk of MSD with age. Several factors might contribute to the decrease in prevalence from the first age group to the second. The youngest workers are generally more often assigned tasks that require less experience but heavier physical demand, and they are prone to MSD also because of the lack of experience. The decrease in the prevalence of MSD after 65 yr of age might be due to the fact that those who still remain in the working force are relatively healthy or that workers change jobs as they become older, especially to jobs with less physical demand, which reduces the occurrence of MSD.

The associations between education level and MSD has been documented for back pain[28–30], and a high education level is generally found to be associated with a decreased risk of back pain. In addition, a high education level was correlated with fewer disability days due to back pain[28], but published literature on MSDs of other body parts was limited. Education is usually related to the job held by the worker, and therefore the association between education level and prevalence of MSD can be in part attributable to job content. In general, workers with lower educational levels are more likely to be blue-collar laborers and thus more likely to develop MSD. In addition, the perception and tolerance of pain might also be related to education[31].

High-Risk Industries

The tasks and work environments in different industries put different body parts at risk for MSD, and therefore the list of the top ten industries with the highest prevalence varied across the body parts, even between any two close ones, such as shoulder and elbow (Table 4). Nonetheless, quite a few industries were among the list for more than

one body part. In particular, "Basic Metal Industries" was ranked among the top ten for all body parts for male workers, but none for female workers. High risks of MSD among male workers in this industry have been reported[32, 33], but little such literature on female workers is available. This suggests that male and female workers have very different tasks in this industry. "Building Construction" was ranked among the top ten for six body parts of male workers and seven of female workers, and its high risks of MSD have been well documented[26, 34–38]. On the other hand, although "Sanitary and Pollution Controlling Services" was ranked among the top ten for six body parts of both genders, its high risks were seldom reported.

In our classification of industries, we used the two-digit codes because the data were coded this way. As a result, some industries might be too broad and contain very diverse workers. Nonetheless, even applying the three-digit BOC codes, the NHIS identified 59 major industries for male workers and 48 for female workers by using the same definition for "major industry" as ours[39]; the numbers were similar to our findings (44 for both genders). Therefore, the two classifications are in fact satisfactorily compatible in terms of identifying major industries. Among the top ten industries with the highest prevalence of back pain identified by NHIS, six of those for male workers were among the top ten for MSD of either upper back or lower back and waist in our study, and three for female workers were similar[39]. But we should note that lists of high-risk industries may change if the classification system changes. For example, whereas "Nursing and Personal Care Facilities" was found to be the top high-risk major industry for work-related back pain of women in the NHIS[39], it is included in "Social and Related Community Services" according to the SICSROC, which was not among the top ten industries with the highest prevalence of back pain in our analysis. "Social and Related Community Services" is a very large industrial category including many industries that are not at high risk for back pain. Therefore, the high prevalence of back pain in "Nursing and Personal Care Facilities" would be "diluted" in our analysis even though health-care workers in Taiwan were found to be at high risk for back pain[40].

Limitations and Significance

There are some limitations to this study. Information on many risk factors for MSD was not collected in the survey, including both personal factors such as body weight, smoking, psychosocial conditions, underlying diseases and conditions, and occupational factors such as work tasks and ergonomic prevention measures[18]. Therefore, we are unable to generate risk estimates adjusted for these factors. Further studies on high-risk industries identified in our study are needed to identify the preventable and controllable risk factors so that intervention efforts can be better devised. In the survey questionnaire, MSD was defined on the basis of the occurrence of subjective soreness and pain, regardless of severity, duration, or frequency. As a result, we were unable to explore the pattern of MSD further. In the survey, inter- and intra-interviewer variations were not assessed. Nonetheless, all interviewers received a series of training before the survey and the questionnaire and interview procedure were standardized to minimize the effects of those variations.

The current study is one of the very few, if any, that are able to provide reliable estimates of the prevalence of MSD of various body parts in the general working population. The results showed that, in addition to back pain, MSDs of other body parts, especially those of the neck, the shoulder, and the hand and wrist, were also prevalent among workers. Our study also identified the high-risk industries for further research and intervention, some of which are similar in different countries. On the other hand, some of the high-risk industries are seldom identified in the literature, and therefore each country should conduct its own study to set research and prevention priorities.

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