Musculoskeletal Symptoms of the Neck and Upper Extremities among Iowa Dairy Farmers

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Background *The prevalence of musculoskeletal symptoms (MSS) among U.S. dairy farmers is relatively unknown. The purpose of this study was to assess the prevalence of neck and upper extremity MSS, and to examine associations between symptoms and dairy operation activities among dairy farmers.*

Methods *Questionnaires were mailed to randomly selected dairy farmers in the State of Iowa, USA. Demographic, site specific MSS, and dairy operation activity information was obtained. Odds ratios and 95% confidence intervals were estimated with logistic regression adjusting for potential confounders.*

Results *Among the participants (N = 341), shoulder MSS were reported most frequently (54%). Neck MSS were significantly associated with manually feeding ($OR_{adj} = 2.29$; 95% CI = 1.09–4.80) and tractors use ($OR_{adj} = 2.17$; 95% CI = 1.05–4.50). Also, wrist/hand MSS were associated with manually cleaning animal stalls ($OR_{adj} = 1.96$; 95% CI = 1.06–3.63).*

Conclusions *Neck and upper extremity MSS were common and associated with common dairy farming practices. Future studies need to more accurately assess exposures to physical risk factors for MSS so ergonomic interventions can be developed.* Am. J. Ind. Med. 51:443–451, 2008. © *2008 Wiley-Liss, Inc.*

KEY WORDS: musculoskeletal disorders; ergonomics; agricultural; occupational; disability

INTRODUCTION

Work-related musculoskeletal disorders (MSDs) of the neck and upper extremity are common among industrial workers, costly, and understudied compared to other MSDs [Palmer and Smedley, 2007; Staal et al., 2007]. Work related neck and upper extremity MSDs have been reported among U.S. agricultural workers [Gomez et al., 2003; Rosecrance et al., 2006; Davis and Kotowski, 2007] and non-U.S. agricultural workers [Gustafsson et al., 1994; Stål et al., 1996; Holmberg et al., 2002, 2003; Pinzke, 2003; Stål and Englund, 2005].

Among agricultural workers, elevated rates of neck and upper extremity MSDs and MSS among dairy farmers, in particular, have been reported [Gustafsson et al., 1994; Stål et al., 1996; Pinzke, 2003]. These studies estimate that over 80% of dairy farmers experience MSS, with milking and feeding tasks being the most physically demanding [Gustafsson et al., 1994; Stål et al., 1996; Pinzke, 2003]. Few studies have assessed neck and upper extremity MSS specifically among U.S. dairy farmers.

Similar to other occupational groups, dairy farmers are frequently exposed to physical risk factors frequently associated with neck and upper extremity MSS and MSDs

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(e.g., forceful exertion, repetition, awkward posture, vibration) [Palmer and Smedley, 2007; Staal et al., 2007]. Although interventions to reduce exposure to these risk factors have been introduced into many areas of the workforce, they are not commonly employed in farming. An exception may be the *parlor* dairy facility, which has been associated with fewer awkward postures of the back and knee compared to the older *stanchion* facilities [Nevala-Puranen et al., 1996]. However, the parlor dairy facility has also been associated with exposure to awkward wrist postures and repetition [Stål et al., 1999]. Hence, the parlor milking facility may be contributing to neck and upper extremity MSS and MSDs among dairy farmers.

The purpose of this cross-sectional study was to estimate the prevalence of MSS of the neck and upper extremity among dairy farmers in Iowa, USA. The secondary purpose was to examine association of neck and upper extremity MSS with dairy operation type (stanchion or parlor) and milking activities.

METHODS

Study Sample

Dairy farmers from five counties in Northeast Iowa were recruited to participate in this cross-sectional study. Approximately half of the total dairy farms in the state of Iowa (1,706 farms) are located within these five counties [National Agricultural Statistics Service, 2002a]. Potential participants were identified from a list of dairy farm owner/operators provided by the Iowa Department of Agriculture and Land Stewardship. For each of the five counties, each potential participant was assigned a computer generated (Excel, Microsoft Corporation, Redmond, WA) random number. The potential participants were then sorted by county in ascending order based on the random number assigned to the participant. Potential participants were then selected sequentially for each county in proportion to the number of farms from each county relative to the total number of farms in all five counties. Using this method, 813 dairy farms (approximately 50% of all dairy farms in the five counties) were selected.

Data Collection Instruments

Participants were asked to complete four self-administered questionnaires: (1) a demographic questionnaire, (2) a farm exposure questionnaire, (3) the Modified Nordic questionnaire [Kuorinka et al., 1987], and (4) the Disorders of the Arm, Shoulder, and Hand (DASH) [Hudak et al., 1996].

Demographic questionnaire

The demographic questionnaire was used to collect information on age, gender, height, weight, and smoking status.

Farm questionnaire

The farm questionnaire was used to collect information about dairy farm activities, including hours-per-day performing dairy operation activities (e.g., milking) and type of milking facility (stanchion or parlor). Participants were also asked to report the commodities produced on their farms as a percentage of their total farm production (e.g., 90% milk, 10% grain). The distribution of commodities produced was used as an indicator of the major farming activity conducted on each farm. Additionally, information was collected on years worked on a dairy farm, off-farm employment including the hours per week and weeks per year working, and type of activities performed at other occupations.

Modified Nordic questionnaire

The Modified Nordic Questionnaire was used to collect 12-month period prevalences of MSS of the (1) neck, (2) shoulder, (3) elbow, and (4) wrist/hand [Kuorinka et al., 1987]. This questionnaire has been widely used [Gustafsson et al., 1994; Anton et al., 2002; Holmström and Engholm, 2003; Merlino et al., 2003; Morken et al., 2003; Rosecrance et al., 2006] and has demonstrated good test-retest reliability [Rosecrance et al., 2002]. Participants were also asked (yes, no) if they saw a physician (M.D., D.O., or D.C.) for their MSS. Additionally, participants were also asked if they experienced lost work time due to MSS, and whether MSS were due to a traumatic injury such as a fall.

Disorders of the arm, shoulder and hand

The Disorders of the Arm, Shoulder and Hand (DASH) is a region specific 30 item questionnaire addressing the impact of upper extremity MSS on activities of daily living [Hudak et al., 1996]. Participants who reported upper extremity MSS on the Modified Nordic questionnaire were instructed to complete the DASH. The DASH questionnaire has been validated repeatedly among individuals with upper extremity MSS [Beaton et al., 2001; Hunsaker et al., 2002; SooHoo et al., 2002; Atroshi et al., 2003].

The information obtained from the DASH included the participant's ability to perform specific tasks (e.g., pushing open a heavy door), as well as the severity of upper-extremity symptoms experienced during the week prior to completing the questionnaire. The DASH scores can range from 0 to 100, with 100 indicating the greatest disability.

Procedures

The four self-administered questionnaires were mailed to each of the 813 farms with a pre-paid return envelope. A cover letter included a request that the questionnaire be completed by the farm worker who performed the majority of the milking operations. Reminder postcards were sent to non-responders

2 weeks after the initial mailing. A second mailing of the original letter, questionnaire, and envelope was sent to the non-respondents 4 weeks after the initial mailing. In order to enhance participation, the participants were entered into a drawing for five $100 prizes. The Institutional Review Board at the University of Iowa (Iowa City, IA) approved this study and participants provided written informed consent.

Statistical Analysis

The dairy operation activities examined in this study were type of milking facility (parlor or stanchion); years worked in a dairy operation; average number of cows milked per day (an indicator for operation size); and hours per year milking, manually feed cows, using a tractor, lifting or carry $\geq$23 kg, manually cleaning animal stalls, and performing artificial insemination. A metric of cumulative standardized years of work in a dairy operation was calculated by dividing the reported number hours per year worked in a dairy operation by 2,000 hr and multiplying the dividend by the reported total number of years worked in a dairy operation. Body mass index (BMI) was calculated as weight (kg) divided by height (m^2).

Most of the dairy operation activity variables were categorized into quartiles based on the distribution within the cohort. Due to small cell sizes, some variables were categorized into tertiles or dichotomized. Pearson correlation analyses were conducted to assess collinearity among all continuous variables prior to categorization. Means, percentiles, and distributions were calculated for the demographic, farm activity variables, and site specific MSS.

Associations between (1) demographic variables and (2) dairy operation activity variables and the four MSS outcomes (neck, shoulder, elbow, and wrist/hand MSS) were initially examined individually with logistic regression models which included age and gender. Demographic or dairy operation activity variables were then entered simultaneously into a final multivariable logistic regression model for the specific MSS outcome if (1) one or more category was associated with a MSS outcome with a probability of $\leq$0.15 or (2) the Mantel–Haenzel test for trend of the association between the specific variable and a MSS outcome had a probability of $\leq$0.15. Modification of the effect of milking facility (stanchion versus parlor) on MSS outcomes by hours milking per year was examined by including a milking facility by hours milking per year interaction in the multivariable models. All statistical analyses were conducted using SAS Version 8.1 (SAS Institute, Cary, NC).

RESULTS

Subjects

Of the 813 questionnaires that were mailed, 341 (41.9%) dairy farmers completed and returned questionnaires, 85 (10.5%) farmers refused, 344 (42.3%) did not respond, 31 (3.8%) no longer worked on a dairy farm, and 12 (1.5%) were returned as undeliverable, resulting in 44% participation (341/(813-31-12)). Information on participant demographics is presented in Table I. The mean age of the dairy farmers was 49.6 years (SD 9.9) and 90% were male.

Dairy Operation Activities

Information on dairy operation activities is presented in Table I. Approximately 70% of farms used a stanchion milking facility and 30% used a parlor milking facility. On average, participants milked 1,203 hr/year (SD 625). The mean number of cows milked per day was 73.7 (SD 64.2).

The mean number of years worked on a dairy farm was 32.4 (SD 11.5). Since participants often reported working on a dairy farm more than 2,000 hr/year, the mean standardized years of work on a dairy farm exceeded the calendar years worked on a dairy farm. The mean standardized years worked on a dairy farm was 65.5 years (SD 31.3). Ten percent of the participants reported working at an off-farm job. Dairy operation products comprised 83% of

TABLE I. Demographic and Dairy Operation Activities (N = 341)

	Number (%) or mean (SD)
Demographic characteristics	
Age (years)	49.6 (9.9)
Gender (male)	305 (90%)
Body mass index (kg/m^2) (N = 300)	27.8 (4.5)
Non smokers (N = 307)	260 (85%)
Ever smokers (N = 307)	47 (15%)
Farm characteristics	
Type of milking facility (stanchion) (N = 338)	238 (70%)
Milking (hr/year)	1202.9 (624.9)
Worked on a dairy farm (hr/day)	11.4 (3.3)
Worked on a dairy farm (days/week)	7.0 (0.4)
Worked on a dairy farm (weeks/year)	51.1 (4.2)
Working on a dairy farm (years)	32.4 (11.5)
Worked on a dairy farm (standardized years)	65.5 (31.3)
Average number of cows milked per day	73.7 (64.2)
Manual feeding (hr/year)	553.9 (430.9)
Tractor use (hr/year)	1148.9 (777.4)
Carrying or lifting $\geq$23 kg (hr/year)	298.1 (320.4)
Manually cleaning stalls (hr/year)	214.6 (205.4)
Artificial insemination (hr/year)	56.4 (110.7)
Herd size (cows/farm)	174.71 (130.67)
Sales from dairy farm products (%) (N = 317)	83 (19)
Primary occupation other than farming	34 (10)
Average age of original stanchion facility	40 (29.3)
Average age of original parlor facility	13.3 (11.3)

the agricultural products sold by these farms, indicating that dairy farming was the major farming activity.

Musculoskeletal Symptoms

Musculoskeletal symptoms were common; the 12-month period prevalence of MSS at any site was 75%. The highest 12-month period prevalence was observed for shoulder MSS (54%), and nearly half (45%) of the participants experienced MSS in at least two or more sites (Table II). The greatest proportion of participants who sought health care due to their MSS was among those who experienced neck MSS (48%, Table III). However, only 3% of the participants who experienced neck MSS reported missing work due to this pain. Across all body sites (neck, shoulder, elbow, and wrist/hand), participants reported that 23–28% of MSS were due to a traumatic injury, with the highest frequency for elbow MSS. The mean DASH score for participants who experienced upper extremity MSS was 12.5 (SD = 10.8).

Associations Between Dairy Operation Activities and MSS

Associations between dairy operation activities and site specific MSS are presented in Table IV.

Neck

Manually feeding livestock and driving a tractor were significantly associated with neck symptoms after controlling for potential confounders. However, tests for trend across categories of these exposure variables were not statistically significant.

Shoulder

Associations between shoulder MSS and milking and manually feeding were suggestive of an effect, but were not statistically significant.

Elbow

A monotonic increase in risk of elbow MSS was observed across the four milking hours per year categories and a near twofold risk of elbow MSS was observed among farmers whose reported milking hours per year was in the highest quartile. In addition, the risk of elbow MSS increased monotonically across the categories of hours lifting ≥23 kg. In comparison to those who reported no carrying or lifting ≥23 kg, those who carried or lifted ≥364 hr per year had a modest, but non-statistically significant, elevated risk of elbow pain.

TABLE II. Twelve-Month Prevalence of Musculoskeletal Symptoms (MSS) by Body Site

Body site (N = 341)	Frequency	%
Neck	148	43
Shoulder	183	54
Elbow	82	24
Wrist/hand	137	40
MSS any site	255	75
MSS in two or more sites	155	45

TABLE III. Lost Work Time, Health Care Use, Traumatic Injury, and Disability Characteristics (N = 341)

	Number (%) or mean (SD)
Neck symptoms (N = 148)	
Lost work due to MSS	5 (3)
Accessed health care due to MSS	71 (48)
MSS was due to traumatic injury	36 (24)
Shoulder symptoms (N = 183)	
Lost work due to MSS	8 (4)
Accessed health care due to MSS	65 (36)
MSS was due to traumatic injury	47 (26)
Elbow symptoms (N = 82)	
Lost work due to MSS	3 (4)
Accessed health care due to MSS	17 (21)
MSS was due to traumatic injury	23 (28)
Wrist/hand symptoms (N = 137)	
Lost work due to MSS	8 (6)
Accessed health care due to MSS	28 (20)
MSS was due to traumatic injury	32 (23)
Disability characteristics	
DASH score (N = 211)	12.5 (10.8)

Wrist/hand

A monotonic increase in risk of wrist/hand symptoms was observed across categories of manually cleaning animal stalls (P-trend = 0.06). A statistically significant increase in risk of wrist/hand symptoms was observed among participants who reported more than 1,275 hr/year of manually cleaning animal stalls after controlling for potential confounders.

DISCUSSION

Musculoskeletal Symptoms

Neck and upper extremity MSS were reported frequently by the dairy operators who participated in this study. Three quarters of study participants reported at least one prevalent MSS. Across all neck and upper extremity sites evaluated, the shoulder was the most common location for MSS (54%). The prevalences of MSS for all body sites among dairy farmers in

TABLE IV. Dairy Operation Activities Associated With Prevalent Musculoskeletal Symptoms

	Experience symptoms					
	Yes	**No**	**Age-gender adjusted OR**	**95% CI**	**Adjusted* OR**	**95% CI**
Neck symptoms	148	193				
Manually feeding (hr/year)						
≤317	32	53	1.00	—	1.00	—
318–445	36	49	1.16	0.62–2.16	1.08	0.56–2.08
446–727	34	24	2.16	1.08–4.33	2.29	1.09–4.80
≥728	46	67	1.13	0.63–2.04	1.19	0.62–2.28
Trend test			$P = 0.50$		$P = 0.71$	
Tractor use (hr/year)						
≤545	32	52	1.00	—	1.00	—
546–1,159	34	50	1.22	0.61–2.42	1.11	0.54–2.31
1,160–1,637	46	39	2.21	1.11–4.41	2.17	1.05–4.50
≥1,638	36	52	1.32	0.66–2.62	1.23	0.59–2.55
Trend test			$P = 0.25$		$P = 0.33$	
Carrying or lifting ≥23 kg (hr/year)						
Zero	30	59	1.00	—	1.00	—
≤0.5–363	59	57	1.89	1.05–3.40	1.64	0.87–3.08
≥364	59	77	1.41	0.80–2.51	1.32	0.70–2.50
Trend test			$P = 0.37$		$P = 0.47$	
Manually cleaning animal stalls (hr/year)						
Zero	37	64	1.00	—	1.00	—
0.4–273	57	52	1.83	1.03–3.25	1.48	0.80–2.74
≥1,275	54	77	1.18	0.68–2.04	0.90	0.48–1.68
Trend test			$P = 0.73$		$P = 0.88$	
Shoulder symptoms	183	158				
Milking (hr/year)						
≤727	32	34	1.00	—	1.00	—
728–1,137	52	52	1.03	0.53–1.92	0.98	0.51–1.86
1,138–1,455	27	14	1.94	0.86–4.39	1.85	0.80–4.27
≥1,456	72	58	1.27	0.69–2.32	1.34	0.71–2.54
Trend test			$P = 0.29$		$P = 0.21$	
Manually feeding (hr/year)						
≤317	43	42	1.00	—	1.00	—
318–445	48	37	1.25	0.68–2.29	1.30	0.69–2.42
446–727	38	20	1.81	0.90–3.62	1.73	0.85–3.54
≥728	54	59	0.89	0.51–1.58	0.84	0.46–1.52
Trend test			$P = 0.72$		$P = 0.49$	
Elbow symptoms	82	259				
Milking (hr/year)						
≤727	11	55	1.00	—	1.00	—
728–1,137	21	83	1.38	0.61–3.31	1.08	0.45–2.58
1,138–1,455	9	32	1.59	0.58–4.33	1.12	0.39–3.24
≥1,456	41	89	2.57	1.19–5.53	1.96	0.86–4.56
Trend test			$P = 0.006$		$P = 0.03$	
Worked on a dairy farm (standardized years)						
≤42	14	68	1.00	—	1.00	—
43–62	19	68	1.39	0.64–3.02	1.33	0.59–2.98
63–86	25	59	2.11	0.96–4.63	1.86	0.81–4.27
≥87	24	64	1.82	0.82–4.06	1.56	0.67–3.65

(*Continued*)

TABLE IV. (*Continued*)

	Experience symptoms					
	Yes	No	Age-gender adjusted OR	95% CI	Adjusted* OR	95% CI
Trend test			$P = 0.11$		$P = 0.36$	
Manually feeding (hr/year)						
≤317	15	70	1.00	—	1.00	—
318–445	24	61	1.92	0.92–4.01	1.73	0.79–3.78
446–727	16	42	1.91	0.85–4.31	1.59	0.67–3.78
≥728	27	86	1.52	0.75–3.11	1.06	0.48–2.30
Trend test			$P = 0.39$		$P = 0.90$	
Carrying or lifting ≥23 kg (hr/year)						
Zero	18	71	1.00	—	1.00	—
0.5–363	23	93	1.05	0.52–2.11	1.08	0.52–2.22
≥364	41	95	1.85	0.96–3.55	1.67	0.83–3.39
Trend test			$P = 0.04$		$P = 0.04$	
Average number cows milked per day						
<40	12	62	1.00	—	1.00	—
40–59	23	69	1.83	0.83–4.05	1.62	0.69–3.76
60–79	25	58	2.50	1.13–5.54	2.12	0.91–4.96
80+	22	70	1.73	0.78–3.84	1.58	0.65–3.86
Trend test			$P = 0.18$		$P = 0.33$	
Wrist/hand symptoms	137	204				
Milking (hr/year)						
≤727	24	42	1.00	—	1.00	—
728–1,137	39	65	1.01	0.53–1.94	0.83	0.42–1.62
1,138–1,455	12	29	0.65	0.28–1.54	0.58	0.24–1.39
≥1,456	62	68	1.52	0.82–2.84	1.35	0.72–2.56
Trend test			$P = 0.13$		$P = 0.19$	
Carrying or lifting ≥23kg (hr/year)						
Zero	30	59	1.00	—	1.00	—
0.5–363	45	71	1.27	0.70–2.30	1.13	0.60–2.13
≥364	62	74	1.75	0.99–3.11	1.45	0.77–2.71
Trend test			$P = 0.05$		$P = 0.63$	
Manually cleaning animal stalls (hr/year)						
Zero	31	70	1.00	—	1.00	—
0.4–273	45	64	1.76	0.97–3.20	1.72	0.92–3.24
≥1,275	61	70	2.17	1.23–3.83	1.96	1.06–3.63
Trend test			$P = 0.009$		$P = 0.06$	

*Adjusted for all remaining variables in the model.

the current study were higher than those reported among European dairy farmers evaluated by other investigators [Gustafsson et al., 1994; Pinzke, 2003]. The greater prevalence of MSS among dairy farmers in the current study may be due to greater hours worked per year or a greater number of cows milked per day in comparison to European dairy farmers. For example, dairy farmers in the current study worked twice as many hours per week and milked more than twice as many cows per day than the farmers studied by Pinzke [2003]. Consequently, the dairy farmers in the current study may have greater exposure to risk factors associated with MSDs and greater risk of developing MSDs, when compared to other dairy farmers.

We are aware of only one prior study in which the investigators determined the prevalence of MSS of the neck and upper extremities among farmers in the U.S. [Gomez et al., 2003]. In that study of farmers in New York State, ''dairy'' was the principal farm commodity for just over half of the farms on which participants worked. Of those working on dairy farms, 35% reported neck/shoulder MSS

and 27% reported hand/wrist MSS. Similar to the current study, factors such as milking and number of cows were associated with either neck/shoulder MSS or hand/wrist MSS. In contrast, Gomez et al. observed a statistically significant positive association between ''Tractor work'' (yes/no) and hand/wrist MSS.

Associations Between Dairy Operation Activities and MSS

One of the primary objectives of this study was to examine associations between dairy operation facilities and activities, such as type of milking facility (stanchion versus parlor) and hours per year milking, and prevalent MSS of the neck, shoulder, elbow, and wrist/hand. Limited associations between MSS and dairy operation activities were observed. Although there was no effect of milking facility type on MSS, hours milking was associated with elbow symptoms. Consistent with this observation, Pinzke [2003] found an association between elbow MSS among female milkers and number of cows milked ($OR_{adj} = 4.0$; 95% CI = 1.1–15.2). They also found that the number of milking machines was associated with elbow MSS among female milkers ($OR_{adj} = 4.3$; 95% CI = 1.1–187.4). Both exposure variables used by Pinzke et al. (number of cows milked and number of milking machines) could be indirect indicators of hours milking.

In the current study, wrist/hand MSS were significantly associated with hours per year manually cleaning animal stalls. Cleaning animal stalls includes tasks such as shoveling and scraping (Tranel L, Personal Communication, 01/10/04). These tasks expose farmers to physical risk factors known to be associated with wrist/hand MSDs, such as forceful hand/arm exertions and extreme wrist postures [Malchaire et al., 1996; Bernard, 1997].

We expected that milking in a parlor facility would increase the risk of shoulder MSS compared to milking in a stanchion facility. Stål et al. [1999] reported that individuals milking in parlor facilities elevated their shoulder at or above 90° more frequently than those working in stanchion facilities. Shoulder elevation in this range increases static loads of the upper back and is a known risk factor associated with shoulder MSDs [Bernard, 1997]. Comparable to our findings, Gustafsson et al. [1994] found no association between type of milking facility (stanchion or parlor) and prevalent MSS.

The mean DASH score was 12.5 (SD 10.8), suggesting that the impact of the MSS on daily activities was low. There are no recommendations for what DASH score constitutes a high disability index, although several studies have reported mean scores ranging from 30 to 50 for patients undergoing medical treatment for upper extremity disorders [Navsarikar et al., 1999; Beaton et al., 2001; SooHoo et al., 2002; Atroshi et al., 2003]. The relatively low mean DASH score may have been the result of study subject selection. In particular, we asked that questionnaires be completed by ''the farm worker who performed the majority of the milking operations.'' Farm workers experiencing substantial disability would likely not be the one who performed the majority of the milking operations.

Limitations

One explanation for the paucity of associations between dairy activities and MSS is that the dairy exposures examined in this study have little or no effect on risk of the MSS ascertained with the Modified Nordic Questionnaire. While possible, other lines of evidence suggest that farming is associated with physical exposures known in other industries to increase the risk of MSS. Several methodological limitations may have attenuated associations observed between dairy farming activities and MSS.

It is possible that the study sample was not representative of all exposed dairy farmers. Participation in the current study was modest (44%), and respondents may have differed in dairy operation exposures or MSS in comparison to non-respondents. Information available from other sources, however, shows similarities between some study participant characteristics and Iowa dairy farmers. Specifically, the ratio of stanchion to parlor milking facilities observed in this study (i.e., approximately 2:1) was consistent with statewide estimates (Tranel L, Personal Communication, 01/10/04). Additionally, study participants reported an average 76.7 milk cows per farm, a value similar to the average of 72.0 milk cows per farm reported by the 2002 Census of Agriculture for the region [National Agricultural Statistics Service, 2002b]. The mean age (49.6 years) and gender (10% female) reported by the participants in this study were similar to demographic data reported for dairy farmers in the Iowa counties in which the study was performed (53 years and 6% female) [National Agricultural Statistics Service, 2002a]. Also, the mean BMI calculated for participants in this study was similar to the mean BMI reported previously among similar farmers [Rosecrance et al., 2006]. Based on these limited comparisons, demographic characteristics of the participating dairy farmers were similar to those available from other sources for dairy farmers of the region. Although somewhat reassuring, these data do not confirm that exposure-effect associations among participants were similar to exposure-effect associations among non-participants. However, the similarities in demographic characteristics does suggest limited sample distortion as a consequence of the modest participation. Regardless of similarities in demographic characteristics, however, participants may still differ from non-participants with respect to exposure to physical risk factors, reporting MSS, and, most importantly, the association between exposure and health outcome.

Another concern with the selection of the study sample was our request (as described above) that the questionnaire be

completed by ''the farm worker who performed the majority of the milking operations.'' It is possible that those who were most affected by adverse physical exposures were no longer performing the majority of the milking operations and did not, therefore, complete the questionnaires. Consequently, the study sample might not have fully represented the most susceptible and most heavily exposed farmers.

Another possibility is that a second or even third occupational affected the MSS reported by the study participants may have been due to a second occupation. However, several factors indicate that the MSS reported in this study were due to dairy farm work. Specifically, only 10% of the participants had another occupation where they worked at least part time. Thus, the likelihood of confounding due to other occupational exposures is low. Additionally, dairy products accounted for approximately 83% of total sales for the farms that participated. The amount of dairy products generated may indicate a farm's predominant type of production. Since this study relied on self-report of exposure, imprecision of the estimate of exposure to farming activities may have attenuated observed associations with neck and upper extremity MSS [Burdorf, 1995; Burdorf and van der Beek, 1999; Riihimäki, 1999].

A limitation of cross-sectional studies such as this, is that a temporal relationship between the exposure variables and MSS can not be established. For example, if work in stanchion operations resulted in MSS, highly symptomatic individuals may have changed to a parlor milking system or left the workforce altogether. Likewise, highly susceptible farmers may have reduced their exposure over time, distorting exposure-effect associations. Therefore, the associations we have reported should be generalized with caution.

CONCLUSIONS

In this study, a higher prevalence of MSS of the neck and upper extremity was observed among dairy farmers in Iowa, USA, than has been reported in previous investigations. The results of this study suggest that the risk of developing elbow MSS may be minimized by decreasing the hours an individual milks. In contrast, risk of developing of upper extremity MSS was not affected by type of dairy facility or several other dairy- or farm-related activities.

Future studies that incorporate a prospective cohort design, additional incentives to increase participation rates, precise measurement of exposure to physical risk factors and potential confounders, and more sensitive and specific ascertainment of health effects will allow for control of biases that may have biased results of this study towards the null.

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