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Work-Related Musculoskeletal Pain and Discomfort Among Livestock Workers: Evidence from the Friuli-Venezia Giulia Region of Italy

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Abstract

Agriculture is a hazardous industry, and working in livestock production has been linked to musculoskeletal disorders (MSDs). However, limited research has examined work-related risk factors contributing to MSDs among livestock workers especially in small and family-owned operations, like most of the companies located in the Friuli-Venezia Giulia (FVG) region of Italy. This cross-sectional study conducted in July 2024 investigates self-reported musculoskeletal pain and discomfort and occupational exposures among dairy and swine farmworkers (N = 50; mean age = 37 years) in FVG. We assessed musculoskeletal exposures, self-reported pain and discomfort, and the use of preventive techniques to maintain musculoskeletal health. Participants reported a high prevalence (80%) of musculoskeletal pain and discomfort, particularly among those working in family operations. While lower back and knee pain were most common, work-related exposures were most strongly associated with pain in the lower back and neck. These findings highlight the need to address occupational health risks related to MSDs in livestock operations, including possible prevention and intervention strategies. This may be especially important for small and family-owned farms where preventive and ergonomic interventions may yield substantial benefits.

Keywords: farmworkers; agriculture; musculoskeletal health; musculoskeletal disorders; occupational diseases; working conditions; north-east of Italy

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1. Introduction

Agriculture remains one of the most hazardous industries worldwide and the most dangerous occupation across many developed countries, even though there has been increased mechanization and initiatives to improve working conditions [1]. Much of the work in agriculture continues to be physically demanding, relying on strenuous manual labor, particularly in smaller operations [1,2]. Employment in the agricultural sector has profound implications for workers' physical and mental health, contributing to a high prevalence of work-related occupational illnesses that have become normalized within farming communities [1,3–6]. In particular, livestock production has been associated with a range of adverse health outcomes and occupational diseases among farmers and farmworkers, including musculoskeletal disorders (MSDs), injuries, zoonotic diseases, chronic health conditions, and mental health challenges, with these effects varying both within and between countries [5,7–12].

1.1. Regional Context: Agriculture and Livestock Production in Friuli-Venezia Giulia

The European Union (EU) ranks among the world's leading agricultural producers and consumers [13]. Italy is among the largest agricultural producers in Europe and has seen a notable increase in agricultural employment over the last decade. In 2024, the sector employed nearly 1 million workers, up 0.7% from the previous year. Over the decade, agricultural employment in Italy rose by 2.9%, while Europe as a whole recorded a 17% decline [14]. Farm distribution and commodity production varies geographically within Italy due to different climatic, sociocultural, and geomorphological conditions found within the country. Livestock farming in Italy is primarily concentrated in the northern region, which hosts about 70% of the national cattle population [15] and nearly 89% of the swine population [16].

The Friuli-Venezia Giulia (FVG) region is located in the northeastern part of the country and serves as a significant agricultural hub, with nearly one-third of its land dedicated to agricultural activities [17]. Animal husbandry is a cornerstone of the regional economy and cultural identity, contributing substantially to the agri-food processing sector. According to the Istituto Zooprofilattico Sperimentale delle Venezie, in 2024 FVG had 1553 cattle/buffalo farms and 1145 swine farms. Herd sizes differed markedly, with 70,960 cattle/buffalo compared to nearly 241,907 swine, reflecting a more intensive swine sector [18].

Within FVG's livestock sector, swine farming holds particular importance, contributing significantly to regional charcuterie traditions and cured meat production. Reflecting the region's rich culinary heritage, local swine production sustains regional food systems, especially in niche markets and in the making of traditional processed pork products such as Prosciutto di San Daniele, an uncooked, unsmoked, and dry-cured ham [19].

1.2. Pain and Discomfort Among Agricultural Workers

Musculoskeletal health refers to the proper functioning of the locomotor system, including muscles, bones, joints, and surrounding connective tissues. MSDs involve impairments in these structures, resulting in temporary or permanent limitations in functioning and participation [20]. Pain and discomfort are common manifestations of MSDs [21]. MSDs can affect various parts of the body; however, low back pain (LBP) is the most prevalent musculoskeletal condition globally and the leading cause of disability worldwide. In 2020, LBP affected an estimated 619 million people, and this number is projected to rise to 843 million by 2050 [20,22]. MSDs can be caused or aggravated by work-related exposures making it a major occupational health concern in agriculture [23,24]. Although most existing research has focused on crop workers [25], evidence from a systematic review showed a higher prevalence of MSDs on livestock farms compared to other agricultural activities [23]. In 2015, about 69% of agricultural workers in the EU-28 (prior to Brexit) reported experiencing one or more MSDs within the previous 12 months, with back pain and muscular discomfort in the upper and lower limbs being most frequently reported [26].

Agricultural work exposes workers to numerous physical hazards that contribute to the development of MSDs and associated health outcomes including chronic pain, disability, absenteeism, presenteeism, and diminished quality of life [24]. Common work-related exposures reported across different agricultural operations include lifting and carrying heavy loads (such as dead animals or containers of milk, cream, or butter), awkward postures, prolonged standing or bending, extended trunk flexion, and the risk of slipping or falling on uneven or slippery surfaces. Other frequent risk factors involve operating machinery, whole-body vibration, repetitive use of long-handled or power tools, and stress [23,27–30]. However, because agricultural work is highly heterogeneous, the types and intensities of exposures vary according to the specific agricultural activity

and the nature of the tasks performed by the worker. For example, research among dairy farmers in the United States has shown differences in exposure to awkward postures within milking facilities, with stanchion milking linked to the greatest prevalence of awkward knee postures [28,31].

1.3. Occupational Health in the Agricultural Sector in Italy and the FVG Region

In Italy, MSDs are the most frequently recognized occupational disease [26]. As of 2017, approximately 1.3% of workers in the Italian agricultural sector had been diagnosed with an occupational disease (1295 cases per 100,000 workers) such as MSDs, skin diseases, asthma, or cancer, with a substantial increase over the previous 14 years primarily driven by a rise in MSD cases which accounted for 74% of all diagnoses [32]. Livestock workers face unique and often higher risks due to animal handling related tasks [32,33].

However, research on health and well-being among livestock workers in the FVG region is limited. Existing studies tend to emphasize both mechanical and biological occupational hazards, such as zoonotic diseases; injuries; and the safety of machinery, facilities, and equipment. Overall, agricultural safety in the FVG region remains a major concern, exacerbated by limited safety awareness among workers, outdated machinery, and ineffective control systems [34–39]. While several studies have assessed occupational hazards in agriculture in FVG, no studies have focused on the work-related risk factors for musculoskeletal pain and discomfort among livestock workers in the region. Improving understanding of musculoskeletal health of livestock workers is crucial, not only because agricultural work is hazardous, but also due to the potential economic and cultural implications for the regional agricultural industry. Therefore, this study aimed to explore musculoskeletal pain, discomfort, and work-related exposures among livestock workers in the FVG region of Italy.

2. Materials and Methods

Data for this analysis are taken from the cross-sectional survey "An exploratory study of health and well-being among livestock workers in the Friuli-Venezia Giulia region of Italy." This project was approved by the University of Nebraska Medical Center's Institutional Review Board (IRB # 0321-24-EP).

2.1. Procedures

Researchers from the University of Nebraska Medical Center in the United States and the University of Udine in Italy partnered to conduct this study. First, we created a list of 31 livestock farms in the FVG region. Then, a convenience sampling approach was used. Out of the 31 farms on the list, we contacted 21 farm owners and discontinued outreach once the target sample size was reached. We contacted farm owners to explain the purpose of the study and ask if they would be willing to allow members of the research team to come onsite to invite workers to participate in the study. Upon agreeing, a date and time to visit the farm was arranged. Of the 21 sites contacted, 12 agreed to participate (response rate: 51.7%).

To be eligible to participate in the study, individuals had to be currently employed on a livestock farm in the FVG region, attained the age of majority in Italy (i.e., be at least 18 years old), and speak Italian or English. Informed consent was obtained from each participant prior to engaging in any research activities. Structured in-person interviews were conducted to gather information about workers' demographic characteristics, physical and mental health, and their work environment. Interviews were completed during July 2024 in either Italian or English, based on the worker's language preference, and were conducted onsite at the farms during working hours.

2.2. Measures

2.2.1. Characteristics of Farm Operations and Workforce Demographics

Information on participants' sex, age, country of origin, relationship status, and education were collected. We asked about the length of time working in agriculture or farming, hours worked per day, and days worked per week. We also asked workers about their primary role on the farm and the types of tasks they performed. Based on the open-ended question, "What is your primary job on the farm?", we grouped those reporting multiple activities into six categories. We also collected information about the farm, including the main agricultural activity (e.g., dairy farm or swine farm), farm ownership type (corporate vs. family-owned), number of head of livestock, and number of workers employed at the farm.

2.2.2. Musculoskeletal Health

Musculoskeletal Exposures at Work. Participants were asked about the frequency of various musculoskeletal exposures at work during the 12 months prior to the date of the survey, such as doing intensive tasks for long periods of time, forceful exertions, repetitive tasks, awkward postures, manual labor, heavy lifting (>than 25 kg), and use of heavy machinery (e.g., farm tractors, payloaders, sprayers). Because there is no established consensus on a precise maximum weight lifting threshold in Italy (given variations in factors such as gender and age), we used a threshold of 25 kg in our study, consistent with previous occupational research examining musculoskeletal health [40–42]. For each item, there were five response options including never, rarely, sometimes, often, and always. These questions were developed based on ergonomic hazards identified in the 23rd World Congress on Safety and Health at Work report, the Criteria for Diagnosis and Attribution of an Occupational Musculoskeletal Disease, and the workplace health and safety survey created by the Institute for Work & Health [43–45]. Responses were collapsed into two categories: (1) low frequency (never, rarely, sometimes) and (2) high frequency (often and always). This procedure was used to ensure that each group contained an adequate number of observations to enhance the robustness and interpretability of analyses [46]. Additionally, this conservative approach emphasizes the risk from repeated exposures compared to more sporadic exposures and aligns with methods applied in previous occupational health research to distinguish between frequent and infrequent exposure to ergonomic hazards [47,48].

Musculoskeletal Pain and Discomfort. Participants were asked, "Did you experience pain or discomfort that affected your work in any of the following body areas during the past 12 months?" Participants had the option to mark all that applied, including neck, shoulders, upper back, elbows, wrist/hands, lower back, hips/thighs, knees, and ankles/feet. A schematic representation of the human body was included in the questionnaire so that participants could indicate precisely the location of the pain. Response options for this section were binary: yes (the participant reports having pain in that specific location) or no (the participant does not report having pain in that specific location). This question was adapted from the Farm and Ranch Health and Safety Survey (IRB #0071-23-EX) developed by the Central States Center for Agricultural Safety and Health (CS-CASH) research team at the University of Nebraska Medical Center and was originally based on the Standardised Nordic Musculoskeletal Questionnaire [49]. Based on this question, we created a binary variable indicating whether participants experienced pain during the past 12 months; participants reporting pain in at least one body area were assigned to the pain group (1), while those reporting no pain in any body area were assigned to the no pain group (0). Average current pain was assessed using the following Patient-Reported Outcomes Measurement Information System (PROMIS)

question, "In the past 7 days, how would you rate your pain on average?" Participants responded based on a 0–10 scale where 0 indicated "no pain" and 10 indicated "the worst pain imaginable" [50]. Based on this question, we created a binary variable indicating whether participants experienced pain in the past 7 days. Participants reporting a pain score of at least 1 were assigned to the pain group (1), while those reporting a score of 0 were assigned to the no pain group (0). The average current pain score was calculated among participants reporting some pain in the past 7 days.

Preventive Techniques to Maintain Musculoskeletal Health. Participants were asked, "Did you use any of the following preventive techniques to maintain your musculoskeletal health during the past 12 months?" Response options included: none, regular breaks, stretching, exercising, good lifting techniques, or other practices (with an option to specify). For analysis, this variable was recoded into a binary yes/no format. Participants were also asked, "Do you get at least 30 min of physical activity outside of work at least three days per week?" with response options of yes or no.

2.3. Data Analysis

Given the exploratory nature of the study, the analyses were designed to descriptively examine the distribution of musculoskeletal pain and discomfort across body regions, the frequency of work-related exposures, and the use of preventive techniques, as well as to explore potential patterns, trends and associations between demographic and work-related characteristics, reported exposures, and musculoskeletal outcomes. Descriptive statistics were used to summarize participants' demographic characteristics and key variables of interest. Bivariate analyses assessed the relationships between (1) musculoskeletal exposures at work and musculoskeletal pain and discomfort (including pain or discomfort reported in each body area assessed in the survey); (2) farm ownership type (corporate vs. family-owned) and musculoskeletal pain and discomfort; and (3) farm ownership type and the number of roles performed at the farm (single vs. multiple). Additional exploratory analyses examined associations between musculoskeletal pain and discomfort and participants' age, years working in agriculture, average number of days worked per week, average hours worked per day, the use of preventive techniques to maintain musculoskeletal health, and engagement in physical activity outside of work. Chi-square tests of association were used for categorical variables, and Fisher's exact tests (2-sided) were used when expected cell counts were less than five. The nonparametric Mann–Whitney U test was used to compare the mean ages, years working in agriculture, average number of days worked per week, average hours worked per day between those with and without pain or discomfort. Ninety-five percent confidence intervals (95% CIs) were built for the true effect sizes. A $p < 0.05$ was considered statistically significant for unadjusted analyses, whereas a $p < 0.05/k$ was used to determine statistical significance following the conservative Bonferroni correction for multiple comparisons (k tests). Analyses were conducted using version 30 of the IBM SPSS statistical software and SAS 9.4 [51,52]

3. Results

A total of 50 livestock workers from 12 farms (8 dairy and 4 swine operations) participated in the study. Most participants were men (82%), single (50%), of Italian origin (78%), and had a mean age of 37.3 years old (SD = 14.0). Most workers were employed on dairy farms (82%), with the majority working on family-owned operations (72%). Table 1 highlights the demographic characteristics of study participants and farm operations.

Table 1. Demographics and farmwork-related characteristics of study participants.

Variables	*N* (%)	M (SD), Min–Max
Sex		
Male	41 (82.0)	
Female	9 (18.0)	
Age (yrs)		37.3 (14.0), 19–65
Country of origin		
Italy	39 (78.0)	
Other (India, Poland, Bulgaria)	11 (22.0)	
Relationship status		
Single	25 (50.0)	
Married	22 (44.0)	
Separated, Divorced	3 (6.0)	
Education		
High School Diploma	21 (42.0)	
Trade school/apprenticeship certificate	14 (28.0)	
Less than high school	11 (22.0)	
Bachelor's degree	3 (6.0)	
Master's degree	1 (2.0)	
Time working in agriculture/farming (yrs)		16.2 (13.1), 1–50
Days worked per week		6.1 (0.6), 5–7
Hours worked per day		9.2 (1.7), 6–15
Type of farm		
Family farm	36 (72.0)	
Corporate farm	14 (28.0)	
Main agricultural activity of the farm		
Dairy farm	41 (82.0)	
Swine farm	9 (18.0)	
Number of head of livestock in the farm		711.5 (756.7), 15–3800
Dairy cows		576.7 (422.6), 110–1200
Swine		1325.5 (1448.1), 15–3800
Number of workers in the farm		10.8 (9.1), 2–42
Activities performed at the farm		
Single activity	23 (46.0)	
Multiple activities	27 (54.0)	
Single activity reported (n = 23)		
Milker	9 (39.1)	
General manager	3 (13.0)	
Calves/Delivery room administrator	4 (17.4)	
Driver (Tractor/Unifeed tank)	4 (17.4)	
Stable manager	1 (4.3)	
Cleaning	1 (4.3)	
Feeding cattle	1 (4.3)	

3.1. Multiple Roles Performed on the Farm

More than half of participants reported having multiple roles or responsibilities on the farm. Diversity in tasks was particularly evident in smaller, family-run farms, where individuals often engaged in multiple roles to ensure operations ran efficiently. An uncorrected statistically significant association was observed between farm type and the number of activities performed by workers ($\chi^2(1, N = 50) = 5.06$, $p = 0.024$). Workers on family-owned farms were more likely to perform multiple activities (63.9%), whereas those employed on corporate farms tended to have more delineated roles and perform single specific tasks (71.4%).

Although workers reporting a single role are reported in Table 1, we organized responses of those that reported multiple roles into six groups. This classification aimed

to provide a clearer understanding of the operational roles commonly performed within mixed farming and livestock enterprises and illustrate the diverse nature of work on farms, especially family-owned operations which are more common within the region. Note that some combinations appear across multiple categories, and the activity groupings reflect the way participants reported them.

- General Non-Specific Farm Duties: Workers who reported performing a wide range of tasks across various aspects of farm operations, without specifying a main role, neither formally, nor de facto. Some responses included: "All needed," "Everything in the farm: management, cleaning, feeding, etc.," "Everything needed," "Everything that is needed," "I take care of all the necessary work."
- Animal Care and Feeding: Roles primarily focused on animal feeding, cleaning, milking, and daily livestock management. Some responses included: "Animal feeding, cleaning," "Taking care of the animals," "Milking, fertilization, cleaning, animal feeding."
- Farm Management and Supervision: Roles reported involved oversight, coordination, or administrative duties in the farm's operations, including management of personnel, stables, or specific departments. Some examples of responses included: "Administration and workers' management," "Administration, supervision, animal feeding, milker," "Co-management of the stable, calves' management, pharmacy administration, (distributor)," "Global farm management, management of the lactation department."
- Mixed Animal and Field Work: Roles that combine livestock care with field or crop-related activities, indicating a division between job responsibilities across fields and livestock areas. Responses included: "Both in the agricultural and livestock fields," "Everything outside (ed.'s note: "of the farm buildings"), from fields to livestock," "Management of the stable and field operations," "Stable and field operation," "Breeder, manager, cultivator."
- Meat Processing and Sales: Tasks related to meat processing, handling, and marketing of animal products. Responses included: "Meat processing, cleaning, feeding, hospital," "Meat processing/sales in the store," "Milker, meat processing/sales in the store."
- Specialized or Technical Operations: Roles that involve the use of machinery or require performing specialized operations. Responses included: "Herd manager and unifeed [mixer-wagon] driver," "Unifeed [mixer-wagon] driver, livestock handler," "Owner, biogas plant conductor, everything outside, field (crop) production."

3.2. Work-Related Musculoskeletal Exposures and Musculoskeletal Pain or Discomfort

Most participants (80%) reported experiencing pain or discomfort that affected their work during the 12 months prior to the survey, while 66% reported pain within the last 7 days, with an average pain intensity score of 2.9 on a 0–10 scale. Although no statistically significant association was found between pain or discomfort and the multiple roles performed on the farm, a (uncorrected) statistically significant association was observed between farm ownership type (corporate vs. family-owned) and the reporting of pain or discomfort, with workers on family-owned farms reporting pain or discomfort more frequently (88.9%) than those on corporate farms (57.1%) ($\chi^2(1) = 6.35$, $p = 0.012$; Fisher's Exact Test, $p = 0.02$).

The most frequently reported sites of pain or discomfort were the lower back (32%) and knees (26%). Exploratory bivariate analyses were conducted to examine the associations between work-related musculoskeletal exposures and reported musculoskeletal pain or discomfort across all body areas assessed in the survey (Table 2). The results indicated that frequent use of heavy machinery (i.e., tractors, payloaders, sprayers) was significantly

associated with the presence of LBP among workers, $\chi^2(1, N = 49) = 9.50$, uncorrected $p = 0.002$. Workers who reported high-frequency use of heavy machinery were nearly nine times more likely to experience LBP compared to those with low-frequency use (48.4% vs. 5.6%). Similarly, workers who frequently performed repetitive tasks were significantly more likely to report neck pain (26.9%) than those who performed such tasks rarely or sometimes (0%), $\chi^2(1, N = 50) = 7.51$, uncorrected $p = 0.006$; Fisher's Exact Test, uncorrected $p = 0.01$. However, this association did not remain statistically significant after applying the Bonferroni correction and should therefore be interpreted as a trend that may reach statistical significance with a substantially larger sample size (current $N = 50$).

Table 2. Associations between occupational exposures and self-reported musculoskeletal pain by body region.

		Pain or Discomfort Experienced That Affected the Work (12 Months Prior to the Survey Date)									
Exposure		General	Neck	Shoulders	Upper Back	Elbows	Wrist/ Hands	Lower Back	Hips/ Thighs	Knees	Ankles/ Feet
Doing intensive tasks for long periods of time	1	0.118	0.384	1	0.657	0.486	0.663	1	1	1	0.663
	2	−0.218	0.103	−0.024	−0.095	0.044	−0.067	−0.048	−0.028	0.036	−0.067
	3	[−0.494, 0.057]	[−0.135, 0.341]	[−0.244, 0.196]	[−0.277, 0.086]	[−0.102, 0.189]	[−0.243, 0.109]	[−0.330, 0.235]	[−0.081, 0.026]	[−0.240, 0.311]	[−0.243, 0.109]
Making forceful exertions	1	0.463	1	0.694	0.692	0.53	0.399	0.157 [c]	1	0.504	0.399
	2	−0.122	−0.045	−0.076	0.042	−0.062	−0.101	0.194	−0.031	0.115	−0.101
	3	[−0.364, 0.121]	[−0.237, 0.147]	[−0.275, 0.122]	[−0.165, 0.248]	[−0.146, 0.021]	[−0.265, 0.064]	[−0.080, 0.469]	[−0.092, 0.029]	[−0.146, 0.375]	[−0.265, 0.064]
Performing repetitive tasks	1	0.728	**0.010** *	0.704	0.42	1	0.669	0.308 [c]	0.48	0.877 [c]	0.409
	2	−0.064	0.269	0.067	0.109	−0.003	0.071	0.135	−0.042	0.019	−0.09
	3	[−0.284, 0.156]	[0.099, 0.440]	[−0.134, 0.268]	[−0.079, 0.297]	[−0.112, 0.106]	[−0.107, 0.248]	[−0.120, 0.390]	[−0.122, 0.038]	[−0.224, 0.262]	[−0.271, 0.091]
Working in awkward postures	1	0.669	1	1	0.34	0.056	0.626	0.29	1	0.708	1
	2	−0.088	0.032	0.005	0.142	0.167	0.059	−0.212	−0.027	0.09	−0.052
	3	[−0.360, 0.184]	[−0.206, 0.269]	[−0.238, 0.247]	[−0.123, 0.407]	[−0.044, 0.378]	[−0.175, 0.292]	[−0.474, 0.051]	[−0.079, 0.025]	[−0.210, 0.391]	[−0.243, 0.139]
Doing frequent manual labor	1	1.000	0.665	0.66	0.171	1	0.314	1	0.245	1	1
	2	−0.050	0.079	0.106	0.189	0.054	0.162	−0.036	−0.083	0.02	0.052
	3	[−0.299, 0.200]	[−0.118, 0.275]	[−0.095, 0.307]	[0.063, 0.315]	[−0.019, 0.127]	[0.043, 0.281]	[−0.341, 0.269]	[−0.240, 0.073]	[−0.263, 0.304]	[−0.139, 0.243]
Lifting heavy objects (>25 kg)	1	1.000	0.31	1	0.071	1	1	0.699	1	0.413	0.242
	2	0.089	0.131	−0.042	0.28	−0.048	0.006	0.065	−0.024	0.137	0.155
	3	[−0.171, 0.350]	[−0.185, 0.447]	[−0.297, 0.214]	[−0.067, 0.627]	[−0.112, 0.017]	[−0.243, 0.255]	[−0.298, 0.429]	[−0.070, 0.022]	[−0.222, 0.496]	[−0.158, 0.468]
Using heavy machinery	1	0.141	0.656	0.697	0.398	1	0.342	**0.002** *[c]	0.367	1	0.639
	2	0.204	−0.07	−0.038	−0.125	0.032	−0.102	0.428	−0.056	0.036	0.073
	3	[−0.043, 0.452]	[−0.271, 0.131]	[−0.246, 0.171]	[−0.344, 0.093]	[−0.030, 0.094]	[−0.295, 0.091]	[0.223, 0.634]	[−0.161, 0.050]	[−0.210, 0.282]	[−0.085, 0.232]

Note. Each cell contains three lines: (1) *p*-value with test indicator, (2) Proportion Difference (Δp = p_exposed − p_unexposed), (3) uncorrected 95% Wald Confidence Interval for the proportion difference. *p*-values from Fisher's Exact test unless marked. [c] (Chi-square, used when all expected cell counts ≥ 5). * $p < 0.05$ (statistically significant at unadjusted level). $p < 0.05/70 = 0.000714$ (Bonferroni correction applied for k = 70 comparisons; no effects remained significant after correction). Proportion Difference = P(pain | high exposure) − P(pain | low exposure). Positive values indicate higher pain prevalence among the high-exposure group. 95% CI computed using the Wald method: $\Delta p \pm 1.96 \times SE$, where $SE = \sqrt{[p_1(1 - p_1)/n_1 + p_0(1 - p_0)/n_0]}$.

Additionally, there was a statistically significant negative association between engaging in physical activity outside of work and experiencing neck pain (Fisher's Exact Test uncorrected $p = 0.043$). This means that workers who reported getting at least 30 min of

physical activity outside of work at least three days per week were less likely to report neck pain compared to those who did not exercise. However, the statistical significance has disappeared after the Bonferroni correction and therefore should be interpreted only as a trend that may become statistically significant if the sample size (currently $N = 50$) be considerably increased.

There was no statistically significant difference in reporting of overall pain or discomfort by age, years working in agriculture, average number of days worked per week, and average hours worked per day; however, an uncorrected significant association was observed between age and wrist/hand pain (Fisher's Exact, uncorrected $p = 0.01$), with workers aged 45 years and older being more likely to report wrist or hand pain compared to those under 45.

Although workers recognized and reported musculoskeletal exposures at work, only 30% of participants engaged in exercise as a preventive technique and 52% reported not using any specific preventive techniques in the 12 months prior to the survey. Table 3 presents descriptive information on work-related exposures, musculoskeletal pain or discomfort, and preventive techniques used by participants.

Table 3. Work-related exposures, musculoskeletal pain or discomfort, and preventive techniques to maintain musculoskeletal health used by livestock workers in FVG.

Variables	N (%)
Frequency of worker exposure to the following situations—often, always (past 12 months)	
Doing frequent manual labor (n = 49)	37 (75.5)
Using heavy machinery (i.e., tractors, payloaders, sprayers) (n = 49)	31 (63.3)
Performing repetitive tasks	26 (52.0)
Making forceful exertions	18 (36.0)
Doing intensive tasks for long periods of time	14 (28.0)
Working in awkward postures (n = 49)	12 (24.5)
Lifting heavy objects (>25 kg)	8 (16.0)
Pain or discomfort experienced that affected the work (past 12 months)	40 (80.0)
Lower back	16 (32.0)
Knees	13 (26.0)
Shoulders	8 (16.0)
Neck	7 (14.0)
Upper back	7 (14.0)
Wrist/Hands	6 (12.0)
Ankle/Feet	6 (12.0)
Elbows	2 (4.0)
Pain or discomfort experienced in the past 7 days (n = 48)	33 (66.0)
Average pain reported in the past 7 days—M(SD), Min–Max	2.9 (1.7), 1.00–7.00
Preventive techniques used to maintain workers' musculoskeletal health (past 12 months) *	
No preventive techniques used	26 (52.0)
Exercising	15 (30.0)
Stretching	5 (10.0)
Regular breaks	4 (8.0)
Other (Massages, Physiotherapy)	2 (4.0)
Good lifting techniques	1 (2.0)
Physical activity outside of work at least 3 days/week	17 (34.0)

Note. N (%) unless otherwise indicated; Average pain presented as M(SD), Min–Max. * Multiple choice question.

4. Discussion

This exploratory study yields meaningful insights into the under-researched area of livestock workers' musculoskeletal health in the FVG region of Italy. LBP and knee pain were most frequently reported by participants. LBP was significantly associated with

the use of heavy machinery such as tractors, payloaders, and sprayers, and neck pain was significantly associated with performing repetitive tasks. However, the statistical significance has disappeared after the Bonferroni corrections and therefore should be interpreted only as a trend that may become statistically significant if the sample size (currently $N = 50$) be considerably increased.

Farm work is well known to require intense physical effort and a high degree of manual labor, placing workers at increased risk for work-related MSDs [4]. Decades of epidemiologic research have demonstrated a consistent association between MSDs and work-related factors, including the type or combination of agricultural activities performed and the frequency, duration, and intensity of physical exposures [53–55]. According to the European Agency for Safety and Health at Work, among all workers in the EU who reported a work-related health problem, 60% identified MSDs as their most serious condition, with back pain (43%) and muscle pain in the shoulders, neck, or upper limbs (41%) being most frequently reported [26].

Notably, back pain has been among the top three global causes of non-fatal health loss (including non-fatal diseases, injuries, and impairments) for nearly three decades [56]. In Italy, between 2014 and 2018, nearly 75% of all occupational disease cases in agriculture were attributed to MSDs, with back pain being the most prevalent condition [57]. The prevalence of back pain among agricultural workers has been linked to various types of exposures, depending on the specific agricultural activity and job role, including the use of heavy machinery and equipment, physically demanding tasks, work-related lifting, awkward postures, and forceful movements [53,58,59]. In a recent study examining farmers' musculoskeletal pain, 70% of the participants were engaged in livestock production, and the lower back was identified as the most commonly affected body region (47.5%) [28]. Among heavy vehicle operators, including agricultural tractor drivers, exposure to whole-body vibration as well as prolonged static and inappropriate postures have been identified as contributors to MSDs, indicating that vibration and body posture may play an important role in pain and discomfort [60–63].

We also found a (uncorrected) significant association between farm ownership type (corporate vs. family-owned) and the reporting of pain or discomfort, with workers on family farms reporting pain or discomfort more frequently (88.9%) than those on corporate farms (57.1%). Although no statistically significant association was observed between pain or discomfort and the performance of multiple farm roles, and we lack sufficient data to determine whether undertaking multiple tasks explains the higher prevalence of pain in family-owned farms where more than half of participants reported engaging in multiple tasks. This finding is important from a public health perspective and warrants further investigation, as workers in family-owned livestock operations, typically family members, tend to share responsibility for a broad range of tasks, manage essential operations with limited support, and may experience heavy workloads while underreporting occupational health conditions. The underreporting of agricultural injuries, particularly those that may be viewed as less severe or a natural consequence of this specific line of work, has been well documented [64,65]. This may in part be due to the limited availability of health services in rural areas, the absence of legislation mandating health surveillance for workers in family-operated and small-scale enterprises, and the lack of specific regulations addressing occupational diseases in the country [32]. Moreover, because family farmworkers are often self-employed, they typically handle regulatory planning, documentation, and reporting themselves. As a result, they may complete these administrative tasks hastily and view them only as bureaucratic burdens rather than as essential to farm operation management and national surveillance efforts [5,66]. However, such reporting may help identify key

problems and opportunities for intervention, with important implications for farmworkers' musculoskeletal health and overall well-being long-term.

In our study, there was no statistically significant difference in overall pain or discomfort reporting by age, meaning that, in most cases, pain was common regardless of age. However, when examining specific body regions, wrist and hand pain was significantly associated with age in an uncorrected model, with individuals aged 45 years and older being more likely to report experiencing pain in this area. In contrast, previous research has reported that workers younger than 45 years are more likely to experience LBP [55]. In 2023, the median age of male and female livestock workers in Italy was around 47–48 years; however, contrary to the trends, our data shows 36% of workers were under 29 years old, and only four participants (8%) were over 60 years old. Data from the VII General Census of Agriculture conducted in 2020, shows that more than half of Italian farm entrepreneurs are over 60 years old, while only 2.2% are younger than 29 years of age [67]. The higher number of young livestock workers in the examined region, when compared to the national statistics, may be explained in part because in Italy more than half of younger farmers have inherited family-owned operations, aligning with census data indicating that the northern regions of the country host the largest share of young farmers [68].

Although our study did not find statistically significant differences in reported pain between types of farm operations (swine vs. dairy), further studies with larger samples sizes should examine specific associations and better characterize the distinct ergonomic hazards faced by these two groups of workers, given their differing occupational exposures and the limited research in this area. While our findings indicate potential MSD risks based on self-reported pain and discomfort among both groups, additional studies using objective physical assessments would be beneficial.

Finally, we found that more than half of the participants had not engaged in any specific measures to prevent musculoskeletal pain and discomfort in the past 12 months. This is consistent with previous research among farmworkers in Italy, where fewer than half of participants (44%) reported preventive actions to reduce the risk of musculoskeletal pain [69]. Likewise, a systematic review on MSDs in the agricultural sector highlighted the widespread lack of preventive strategies and underscored that preventing MSDs and improving working conditions could enhance the sustainability of agricultural operations, including livestock production [23]. Engaging in physical activity outside of work is an important preventive strategy to promote among livestock workers.

4.1. Implications

Italy, a country belonging to both the G20 and G7, is expected to prioritize workers' well-being through proper training and funding of occupational disease prevention initiatives. As such, the findings of this study provide a foundation for identifying key areas for future research and guiding actions to raise awareness among workers, employers, and relevant authorities. Findings from this study may inform organizations working to improve the health and well-being of livestock workers in Italy, particularly in northeastern regions that share similar farm organization and territorial characteristics, such as FGV, Trento, and Liguria [67].

The development, adaptation, and implementation of activities, programs, and strategies, especially those centered on safety training, ergonomics, and the importance of physical activity, are critical for this worker population. Aligned with the Total Worker Health approach, it is essential to prioritize the design of work environments that minimize or eliminate health and safety hazards while actively promoting worker well-being [70]. Direct engagement with farm owners and farmworkers may improve uptake of these strategies; however, a recent study of farmworkers in northern Italy found that there was

limited collaboration between farmers and health and social professionals on projects to benefit the farming community [71]. Local health agencies should proactively engage with agricultural operations, including both farm owners and laborers, to better understand the work context and identify opportunities for prevention. Given that many farms are small, family-owned operations, it is crucial to recognize potential resource limitations and develop tailored strategies that align with their capacities, while also facilitating access to external support when necessary.

Promoting preventive strategies at both the individual and farm level, such as ensuring regular breaks, encouraging stretching and warm-up activities prior to beginning the day's work, integrating job and/or task rotations to reduce the impact of repetitive work, and providing training on proper lifting techniques and self-management of chronic pain may help workers prevent or reduce the impact of MSDs associated with job-related tasks. Additionally, incorporating specialized curricula on health and safety in agricultural schools would also equip future agricultural professionals with the knowledge and mindset needed to implement changes that promote the well-being of agricultural communities in the region.

Another potential approach for reducing MSD-related risks in agriculture is the use of assistive technologies such as exoskeletons. Although their adoption in agricultural settings remains limited, several studies have begun to examine their applicability and effectiveness [72,73]. Further design improvements, including enhanced compatibility with work clothing, increased flexibility across diverse farm tasks, easier donning and doffing, and consideration of the social and cultural context may be required to ensure these technologies are suitable for agricultural work [74]. To the authors' knowledge, no farm operations in FVG have begun to use exoskeletons. A deeper understanding of the specific risk factors associated with various livestock production activities in the region, including differences in levels of farm mechanization as well as more research on the prevalence and severity of MSDs among this population of agricultural workers is needed.

4.2. Limitations

A primary limitation of this study lies in its exploratory cross-sectional design and relatively small sample size. While such an approach is valuable for generating hypotheses and identifying preliminary trends, it is highly descriptive and the ability to draw general and definitive conclusions is limited. Because of the small sample size, exposure variables were dichotomized to address sparse data and ensure the validity of statistical testing. While this approach improves statistical stability, it may introduce non-differential misclassification by grouping heterogeneous exposure levels, particularly for individuals reporting "sometimes" exposure. However, this categorization was intended to distinguish between intermittent and more sustained exposure patterns, which are more likely to be relevant for musculoskeletal outcomes. Future studies with larger sample sizes should retain the full ordinal structure of exposure variables or apply alternative modeling strategies to better capture exposure gradients. Given that this study used a convenience sampling approach, the findings can only be generalized to the population from which the sample was drawn and to individuals who share similar characteristics with those in the sample [75]. Because the study focused on livestock production in the FVG region of Italy, where most participants were employed on family-owned farms, findings may not be generalizable to other regions, countries, or agricultural production systems. As the study was confined to dairy and swine production, it is important to interpret the results with caution, and the identified occupational risks and health conditions cannot be assumed to apply uniformly across other groups of livestock workers. Finally, we used self-reported measures of pain and discomfort. Although subjective measures provide valuable insight

into workers' experiences and are useful for capturing the personal impact of pain, they are subject to bias. Objective assessments of pain, discomfort, and physical function are needed in future studies.

5. Conclusions

Our findings indicate a high frequency of self-reported musculoskeletal pain and discomfort that affected livestock workers in the FVG region of Italy. We found some (uncorrected) significant associations between musculoskeletal pain and discomfort and workplace exposures. These results underscore the need to further study occupational health risks related to MSDs in livestock operations, with particular attention to family-operated farms, where preventive measures and ergonomic interventions could have a meaningful impact. Training and additional resources may help to address MSDs and institutionalize preventive measures on the farm, including improvements to work organization and design; administrative practices; and technology.

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Abbreviations

The following abbreviations are used in this manuscript:

CS-CASH	Central States Center for Agricultural Safety and Health
EU	European Union
FVG	Friuli-Venezia Giulia
LBP	Low Back Pain
MSD	Musculoskeletal Disorder
PROMIS	Patient-Reported Outcomes Measurement Information System

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