Environmental discomfort and musculoskeletal disorders

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Background Musculoskeletal disorders (MSDs) are the most common occupational disease in Europe, with high prevalence among hospital workers. Both environmental and psychosocial work factors may impact significantly on the development and exacerbation of MSDs.

Aims To evaluate whether environmental factors at work are associated with MSDs in hospital workers and to investigate potential interactions between environmental and psychosocial risk factors in the workplace that are associated with MSDs.

Methods A cross-sectional investigation was performed using the Nordic questionnaire to assess MSDs, the IAQ/MM-040 indoor air questionnaire for environmental factors, the demand–control model for job strain and the Goldberg questionnaire for anxiety and depression. The association between environmental factors and MSDs was studied using logistic regression analysis. In addition, the interactions of environmental factors with strain, anxiety and depression for MSDs were examined.

Results Environmental complaints were associated with MSDs. The strongest associations were found between temperature complaints (OR 2.73), noise and light complaints (OR 2.22), other environmental complaints (OR 3.12) and upper limb disorders. A significant interaction between temperature complaints and strain for upper limb disorders (F = 9.52, P < 0.05) was found.

Conclusions To prevent MSDs, a multi-level approach is needed, including environmental measures and interventions directed to both psychosocial and organizational factors.

Key words Anxiety; depression; hospital workers; indoor environment; job strain; MSDs; work environmental factors.

Introduction Musculoskeletal disorders (MSDs) are the most common occupational disease in the European Union [1]. Data show MSDs to be the most frequent causes of sickness absence, accounting for between 42 and 58% of all work-related illnesses [2]. Thus, work-related MSDs cause not only individual suffering but also have serious economic effects on business and social costs to European countries.

Studies report a high prevalence of MSDs among hospital workers, especially among nurses, with a prevalence ranging between 43 and 70% [3,4]. Besides manual handling of patients and weights, that undoubtedly constitutes the main physical hazard for MSDs, other physical factors making the working environment uncomfortable might also play a role in the development of MSDs. The World Health Organization defined work-related MSDs as a problem of the locomotor apparatus resulting from a number of factors and strongly affected by the work environment and the circumstances of work performance [5].

Previous studies show that environmental factors such as temperature complaints can impact significantly on the development and exacerbation of MSDs [6,7]. Psychosocial work factors as well have emerged as important risk factors for MSDs [8,9]. One widely studied psychosocial factor that has been shown to be associated with MSDs is job strain, defined by the job demand–control model (JDC). The JDC model states that employees working under high job strain (a combination of high work demands and low job control) have a higher risk of health problems, including MSDs [10–12]. Several previous studies suggested that psychological disorders such as anxiety and depression can affect the occurrence of MSDs [13,14].

The aim of this study was (i) to evaluate whether environmental factors at work are associated with MSDs...
in hospital workers and (ii) to investigate potential interactions between environmental and psychosocial risk factors in the workplace that may be associated with MSDs.

Methods

Three Italian hospitals located in the Lazio region were studied; this cross-sectional survey was part of a longitudinal study of workers. During periodical medical examination at work, participants were invited to compile a questionnaire concerning the occurrence of MSDs, psychosocial factors at work and physical environmental factors in the workplace. In the subsequent physical examination, MSDs were assessed and subjects having no objective signs were invited to revise their answers. The survey was carried out between autumn 2006 and autumn 2007. The study protocol was approved by the Ethics Committee of the Catholic University Rome School of Medicine, Rome, Italy.

Musculoskeletal complaints (chronic MSDs) were measured by the Italian version of the standardized ‘Nordic questionnaire’ [15]. Participants were asked to assess in which part of the body (neck, shoulder, elbow, wrist, hands, high back, low back, thigh, hip, knee, ankle and feet) they had experienced recurrent pain during the previous 12 months. The questionnaire is composed of a scale of nine binary items, with the category ‘yes’ defining presence and ‘no’ defining absence of musculoskeletal symptoms. In this study, we considered only the MSDs affecting the ‘upper limbs’ (that included neck, shoulder, high back, elbow, wrist and hands) and the ‘low back’. We excluded ‘lower limb’ disorders because they usually have a low prevalence in working populations and they are seldom job related.

The environmental section of the IAQ/MM-040 indoor air questionnaire [16,17] was used to study the participants’ experiences of the environmental conditions in the workplace, as well as on the symptoms attributed to the work environment. The environmental complaints were investigated with the following question: ‘Have you been annoyed in the last 3 months by any of these factors in the workplace?’ followed by a list of environmental factors: draughts, temperature, dry air, stuffy air, unpleasant smells, static electricity, passive smoke, noise, light and dust. There were three alternative response categories to the question: 1: no, never; 2: yes, sometimes and 3: yes, often, every week. We grouped environmental complaints into three categories and calculated a mean for each category: temperature complaints (draughts, too high temperature, too low temperature, temperature changes; cronbach’s alpha $\alpha = 0.59$ for this sample), noise and light complaints (noise, glare; $\alpha = 0.53$) and other environmental complaints (stuffy air, dry air, unpleasant smells, static electricity, passive smoke, dust; $\alpha = 0.76$).

Strain was measured by the Italian version [18] of the demand–control model [19] that was composed of two scales: ‘the psychological demand scale’ with five items (alpha reliability was 0.66) and the ‘control scale’ with six items ($\alpha = 0.63$). Participants were defined as having ‘high job strain’ if they scored high on the job demands and low on the job control (defined as above the median score on the respective scales).

‘Anxiety and depression’ were assessed using the Italian version [20] of the Goldberg questionnaire [21] that includes two scales of nine binary items; a score of 1 is recorded against each question answered in the affirmative. People with anxiety scores of 5, or depression scores of 2, have a 50% chance of having a clinically important disturbance; above these scores, the probability rises sharply. Consequently, we classified as ‘anxious’ those workers who scored $\geq 5$ and as ‘depressed’ those workers who scored $\geq 2$. Cronbach’s alpha was 0.83 for the anxiety scale and 0.79 for the depression scale.

Socio-demographic characteristics such as age, gender, length of employment and profession were obtained from the questionnaire as well. Length of employment was measured as number of years for which the employee had had that profession. Professions were divided into five categories: (i) physicians, (ii) nurses, (iii) biologists and technicians, (iv) white collars and (v) blue collars.

The association between environmental factors (temperature complaints, noise and light complaints and other environmental complaints) and MSDs (upper limb disorders and low back disorders) was studied using logistic regression analyses in four steps. Model 1 analysed the univariate effects and Model 2 was adjusted for age, gender, profession and length of employment. Model 3 was additionally adjusted for anxiety and depression. Finally, Model 4 was additionally adjusted for strain. In addition, we examined the interactions of environmental factors with strain, anxiety and depression for MSDs. Interaction analyses were adjusted for age, gender, profession and length of employment. To examine possible gender differences, we also analysed whether there were significant interactions between environmental variables and gender for MSDs. If a significant interaction was present, we did the analyses separately for men and women regarding that environmental complaint. All the statistical analyses were performed with PAWS/SPSS package (release 17.0).

Results

A total of 1909 workers were invited to participate in the study; 165 workers gave incomplete responses or refused to participate giving a final response rate of 91%. The sample consisted of 1744 hospital workers (767 male, 977 female workers; age 44.9 ± 8.9 years) including nurses (60%), physicians (18%), technicians and biologists (8%), white collars (11%) and blue collars (3%). Table 1 describes the sample characteristics. Of the participants, 56% were women, age ranged from 26 to 65 years (mean 45 years), and average work tenure was slightly <12 years.
More than half of the respondents (66%, \( n = 1151 \)) reported upper limb disorders and more than one-third of respondents (39%, \( n = 675 \)) reported low back disorders in the 12-month period prior to examination. Less than 30% of the respondents were classified as suffering from anxiety or depression.

Logistic regression (Table 2) showed that environmental complaints were associated with MSDs. Temperature complaints were associated with upper limb disorders (OR 2.73, 95% CI 2.24–3.33). Noise and light complaints (OR 2.22, 95% CI 1.86–2.66) and other environmental complaints (OR 3.12, 95% CI 2.49–3.91) were also associated with upper limb disorders. These associations were robust to adjustments for age, gender, profession, length of employment, anxiety, depression and even job strain. There was also an association of temperature complaints (OR 1.76, 95% CI 1.48–2.11), noise and light complaints (OR 1.51, 95% CI 1.29–1.76) and other environmental complaints (OR 2.24, 95% CI 1.83–2.75) with low back disorders. In the fully adjusted model, however, the association between noise and light complaints and low back disorders attenuated being no longer statistically significant (OR 1.15, 95% CI 0.97–1.37).

We found a significant interaction between temperature complaints and strain for upper limb disorders (\( F = 9.52, P < 0.05 \)). Additional analyses in different strain categories showed that the association between temperature complaints and upper limb disorders was strongest among high strain (high demands–low control) group (OR 3.38, 95% CI 2.02–5.67) and weakest among passive jobs (low demands–low control) group (OR 1.30, 95% CI 0.85–1.99). OR for the group with low demands and high control was 2.50 (95% CI 1.65–3.80) and for the group with high demands and high control it was 2.47 (95% CI 1.61–3.78). Other interactions were not significant.

The interactions between gender and all environmental complaints were all non-significant for both upper limb disorders and low back disorders. Thus, analyses were not done separately for men and women.

### Table 1. Study characteristics

<table>
<thead>
<tr>
<th></th>
<th>( N )</th>
<th>%</th>
<th>Mean (SD)</th>
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<tbody>
<tr>
<td>Gender</td>
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<tr>
<td>Women</td>
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<tr>
<td>Men</td>
<td>767</td>
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<td>Nurses</td>
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<td>Technicians and biologists</td>
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<td>White collar</td>
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<td>Blue collar</td>
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<tr>
<td>No</td>
<td>593</td>
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<td>Yes</td>
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<td>Noise and light complaints</td>
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<td>(range 1–3)</td>
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<tr>
<td>Other environmental</td>
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<td>complaints (range 1–3)</td>
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<td>Strain</td>
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<td>High demands–low control</td>
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<td>Anxiety</td>
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<td>No</td>
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<td>Depression</td>
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### Table 2. Association between environmental factors and MSDs

<table>
<thead>
<tr>
<th></th>
<th>Model 1 (unadjusted) OR 95% CI</th>
<th>Model 2(^a) OR 95% CI</th>
<th>Model 3(^b) OR 95% CI</th>
<th>Model 4(^c) OR 95% CI</th>
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<tbody>
<tr>
<td>Upper limb disorders</td>
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<tr>
<td>Temperature</td>
<td>2.73 (2.24–3.33)</td>
<td>2.45 (1.97–3.03)</td>
<td>2.04 (1.64–2.54)</td>
<td>1.92 (1.53–2.40)</td>
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<td>Noise, light</td>
<td>2.22 (1.86–2.66)</td>
<td>2.10 (1.74–2.55)</td>
<td>1.76 (1.45–2.15)</td>
<td>1.68 (1.38–2.05)</td>
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<tr>
<td>Other</td>
<td>3.12 (2.49–3.91)</td>
<td>2.85 (2.23–3.64)</td>
<td>2.17 (1.68–2.80)</td>
<td>2.03 (1.57–2.63)</td>
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<tr>
<td>Low back disorders</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td>1.76 (1.48–2.11)</td>
<td>1.58 (1.31–1.91)</td>
<td>1.37 (1.12–1.66)</td>
<td>1.31 (1.07–1.60)</td>
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<tr>
<td>Noise, light</td>
<td>1.51 (1.29–1.76)</td>
<td>1.41 (1.20–1.66)</td>
<td>1.21 (1.02–1.43)</td>
<td>1.15 (0.97–1.37)</td>
</tr>
<tr>
<td>Other</td>
<td>2.24 (1.83–2.75)</td>
<td>2.18 (1.75–2.71)</td>
<td>1.75 (1.39–2.21)</td>
<td>1.66 (1.31–2.09)</td>
</tr>
</tbody>
</table>

\(^a\) Model 2 was adjusted for age, gender, profession and length of employment.

\(^b\) In addition to age, gender, profession and length of employment, Model 3 was additionally adjusted for anxiety and depression.

\(^c\) In addition to age, gender, profession, length of employment, anxiety and depression, Model 4 was additionally adjusted for strain.
Discussion

Our findings showed that physical environmental factors in the workplace were related to MSDs. In addition, a strong interaction effect between environmental and psychosocial risk factors affecting MSDs was found. These results not only support previous studies that have linked MSDs with environmental and psychosocial work factors [6–9] but also extend them by showing that the relative excess risk from exposure to both sets of factors was greater than the sum of the relative excess risk from high exposure to only one set of factors (either environmental or psychosocial). Problems in the upper limbs seemed to be more strongly affected by the effects of environmental and psychosocial factors than low back pain.

The exact mechanism through which environmental and psychosocial stress factors at work relate to MSDs is not known. Several pathophysiological pathways have been hypothesized for psychosocial stress factors [22,23]. The most accredited hypothesis is that high mental and psychological stress may increase muscle tension and decrease micropauses in muscle activity. This may lead to muscle fatigue, even in cases of low loads due to continuous firing of low threshold motor units, which are triggered not only by low level physical loading but also by mental loading [23]. Moreover, responses of the central nervous system to job stress may amplify painful sensations resulting in a higher prevalence of MSDs. Previous studies have shown that the central body regions, especially neck and shoulder, are the most vulnerable to increased muscular tension and its adverse effects on musculoskeletal symptoms [24].

On the other hand, only a few studies have investigated the association between environmental factors and MSDs and the pathophysiological pathways through which environmental factors can affect MSDs. It has been shown that both ‘heat stress’ [25] and ‘cold stress’ [6,7] have adverse effects on workers health (including musculoskeletal symptoms) and job performance, causing irritability, carelessness and a feeling of fatigue [26]. Heat is a physical hazard that can pose a problem in almost any workplace, especially during the warm months. Working in hot environments without being adequately acclimated increases workers’ thermal stress [27]. Non-acclimatized individuals decrease their performances when room temperature exceeds 19–22°C, with the upper limit for efficient function at ≈25°C [26]. Even workers performing a standard office task of typing have shown to decrease their productivity up to 50% when the room temperature has increased from 20° to 24°C [25]. An experimental study on female workers pointed out that environmental heat impacts significantly upon the thermoregulatory and muscle fatigue profiles of workers performing both strenuous and sedentary light motor tasks, usually not associated with fatigue process [25]. The mechanism through which heat causes MSDs has not been clarified yet. It can be hypothesized that heat—through sweat—causes salt depletion and water and electrolyte imbalance resulting in muscle cramps that are followed by muscle soreness, stiffness and reduced mobility. Moreover, air draughts in hot environment can be a further factor contributing to MSDs causing painful muscle contractures and reduced mobility.

Hospital interior design aims to create a ‘therapeutic environment’ for patients, making hospital stays as unthreatening, comfortable and stress-free as possible. Setting the indoor temperature at a comfortable level, admitting ample natural light wherever feasible and providing views of the outdoors from every patient bed are important aspects to create a therapeutic interior. Unfortunately patients’ needs often contrast with hospital workers’ needs. For instance, an indoor temperature set at 24–26°C is comfortable for patients wearing light clothes and having a reduced motor activity but it is very uncomfortable for hospital workers wearing a gown and performing heavy tasks. Moreover, in the hospitals involved in our study only the newest units were equipped with mechanical ventilation. In such environment, heat discomfort impacts significantly on workers health and well-being.

Some limitations should be taken into account in interpreting our results. Firstly, this analysis is based on a cross-sectional survey and is therefore not a basis for drawing any causal inferences. The results of the present study should be confirmed in the future with a prospective study design. Secondly, self-reports can lead to concerns about their validity. People affected by MSDs may develop negative mood that could cause a worse perception of the work environment. However, we tested the effects of psychological states, such as depression and anxiety, which are commonly correlated with negative mood, and they did not account for the association between environmental variables and MSDs. However, other psychological factors, included in the wide area of negative affectivity and neuroticism, could inflate the observed relationship between musculoskeletal complaints and environmental factors.

In surveys where self-report questionnaires are used to collect perceptual measures derived from the same respondent, common method variance (CMV), i.e. ‘variance that is attributable to the measurement method rather than to the constructs the measures represent’ [28] may also be a concern. Although researchers generally agree that CMV has the potential to affect the results of a single-method study, no consensus exists about the seriousness of such biases. The specific details of the research methodology are clearly relevant in determining the likelihood and degree of common method bias. For this reason, we chose a different presentation for environmental and musculoskeletal complaints: while the former were simply indicated in a list, the latter needed to be confirmed after objective examination during the medical visit.
In conclusion, MSDs constitute a complex condition influenced by individual, environmental, psychosocial and organizational factors that can interact and consequently increase the risk. In order to prevent occupational MSDs, a multi-level approach is needed including environmental measures and interventions directed to both psychosocial and organizational factors. ‘Healthy employees in a well-functioning work environment’ should be the goal to pursue in any workplace.

**Key points**

- Musculoskeletal disorders in hospital workers are strongly affected by both environmental and psychosocial factors at workplace.
- Environmental and psychosocial factors can interact, increasing significantly the risk of musculoskeletal disorders.
- The strongest interaction was found between temperature complaints and job strain for upper limb disorders.

**Conflicts of interest**

None declared.

**References**


