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ORIGINAL PAPER

# LOW-TEMPERATURE HEALTH HAZARDS AMONG WORKERS OF COLD STORAGE FACILITIES IN LAHORE, PAKISTAN

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**Abstract**

**Background:** Cold storage facilities are the most common workplaces that produce artificially cold work environments and are associated with different adverse effects on human health, work productivity and the occurrence of accidents and injuries. The aim of this study was to measure the antagonistic health effects on workers, so that common factors causing abnormal symptoms could be determined, and to gather basic information to monitor the associated health risks from the exposure to cold work environments. **Material and Methods:** A cross-sectional analytical study was conducted to investigate the occurrence of cold-related adverse health effects, musculoskeletal symptoms, skin problems, injuries, respiratory illnesses, general hygiene and occupational environment related to cold indoor workplaces, using the *Standardized Nordic Questionnaire*. A total of 200 subjects took part in this study, including 100 exposed and 100 unexposed to cold environments. A 1-way analysis of variance (ANOVA) and a t-test were applied to measure statistical differences and to differentiate the cases where variations occurred, using SPSS 16. **Results:** The study revealed that a longer and constant exposure to extremely cold indoor work environments significantly increased ($p < 0.001$) the cold-related symptoms and musculoskeletal disorders which ultimately reduced ($p < 0.01$) the efficiency, effectiveness, performance and work ability of the exposed workers. **Conclusions:** The study disclosed various adverse cold-related complaints of the studied subjects who were exposed to extreme cold conditions during a maximum number of working hours. The most consistent problems were related to musculoskeletal discomfort, skin problems and respiratory abnormalities. Med Pr. 2020;71(1):1–7

**Key words:** musculoskeletal disorders, work productivity, hypothermia, skin problems, cold-related complaints, respiratory illnesses

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## INTRODUCTION

Cold is the profound risk factor pertinent to both indoor and outdoor activities in food industries. A cold indoor environment remains constant throughout the year and affects the quality of work performance of the exposed workers [1]. Cold exposure can be a provoking factor that activates symptoms of tissue impairment, frostbite and hypothermia. It also includes certain factors like cold, intense physical workout, clothing and climate. Socio-economic and individual factors make it more severe [2]. Hypothermia is mostly associated with the fall in the core body temperature <37°C [3]. Muscle disturbances, including pain in the neck, knees, shoulders and lower back, the swelling of muscles, cramps, movement restraints, muscle weakening, and paresthesia, are some of the musculoskeletal complaints reported in cold indoor workplaces [4]. In cold surroundings, the musculoskeletal complaints can be due to the synergistic effect of repetitive muscle movements and cold exposure that results in increased muscle sprain and fatigue [5]. Skin problems due to lower temperature exposure include erythema, physical urticaria and chilblains. Skin changes due to a chronic disease cause an increased sensitivity of the skin to cold, resulting in pain, poor work performance, discomfort and injuries [6]. People working in cold storage facilities have reported many health problems due to continuous cold exposure [7]. Cold exposure may affect various organs, such as the respiratory system or the musculoskeletal system, and can cause skin problems, frostbite, trench foot, chilblains, and hypothermia [8]. Low temperatures decrease the performance of workers [9]. The cooling of muscles causes reduction in the power and performance of workers [10]. In freezing conditions, the stiffness of joints occurs as a result of high viscosity levels

of synovial fluids, following which the muscles have to exert a greater force to move joints, which ultimately causes joints pain and discomfort [11]. Cold exposure increases the level of blood pressure in healthy persons. This can be more stressful for the whole body as it increases blood pressure that is the main cause of many cardiovascular problems [5]. Skin disorders which are temperature dependent include erythema, physical urticaria, chilblains, and cold panniculitis. A long-term skin disease may alter the skin function and make it sensitive. It has been suggested that low humid conditions intensify the problem of dry skin [12]. However, in Pakistan, research studies on cold work environments and associated adverse health effects are limited.

The purpose of this study was to investigate the occurrence of cold-related adverse health effects and musculoskeletal disorders by imparting fundamental information and observing health risks following cold exposure.

## MATERIAL AND METHODS

### Subjects and ethics

This research work was conducted from January to September 2018 after getting the ethical approval from the Department of Environmental Science, Lahore College for Women University, Lahore, Pakistan. At the inception of this cross-sectional study, a survey was conducted regarding different cold storage facilities for frozen food items, in the vicinity of Lahore. Those facilities were selected when the quantum of frozen items and turnover were relatively higher compared to others. Further from these facilities, workers were randomly selected and, following the random selection, only those workers were chosen for the study who were willing to participate. Written consent was obtained from the subjects before their participation. All the subjects were informed on the purpose of the study. Various observations were made about the different sections of cold storage areas, the workplace settings of workers and their surrounding environment. The exposed subjects included those persons working in indoor temperatures ranging −20–(−30)°C. A total of 200 subjects were selected for this study. The participants in the first group comprised (N = 100) the exposed subjects from different sections of cold storage facilities, assessed for cold-related health problems. The male workers exposed to cold work environment, aged >18 years, were included in the study. The participants in the second group (N = 100) were the subjects who did not have any exposure to cold indoor environment, referred to as the unexposed group. The unexposed subjects included workers and clerical staff dedicated to performing lifting, loading and unloading operations in an outdoor environment of cold storage facilities. They were basically multi-taskers involved in various tasks, such as record-keeping, the preparation of gate passes or data entry in computers, as well as document handlers, telephone operators, peons, unskilled workers, etc. The subjects from both the exposed and unexposed groups with known chronic and systemic diseases were excluded from the study. All the exposed subjects worked for 8 h per day and 6 days per week. The exposure time for workers in the cold storage area was 60 min, followed by a rest of 60 min. The main tasks in the cold storage rooms were the lifting, loading, stacking and unloading of frozen food products. The top management of the cold storage facilities provided protective clothing to the workers, comprising a working overall, gloves, thick socks and boots to cope with excessive cold. However, such clothing and equipment was manufactured locally and was not in compliance with any specific standards. In turn, the unexposed group used normal routine clothes without any extra prevention.

### Measurements

A self-administered questionnaire was developed as an interview tool to collect particular information from the subjects under analysis. The questionnaire included both open-ended and close-ended questions. A questionnaire interview was carried out on socio-demographic as well as cold-related occupational health problems, musculoskeletal disorders, cold-related skin injuries, respiratory illnesses, general hygiene, and the occupational environment of workers, while working in cold indoor conditions. A health-check questionnaire on cold-related subjective symptoms and skin allergies was also performed among the workers. The questions concerned changes in the color of fingers, pain in the hands and feet, the effects of cold on work performance, concentration, and sensitivity of the body to cold. Information related to skin problems, such as sensitivity of the skin to cold, stiffness, crack, itching and cooling, and the occurrence of frostbite or frosting in the subjects exposed to cold indoor environment, was also included. The questions about the musculoskeletal symptoms were adopted from the *Standardized Nordic Questionnaire* [13].

The questionnaire included symptoms related to pain or discomfort in different body parts during the last

12 months, and pain in the lower extremities, neck and shoulder during work. The questionnaire also inquired about whether the cold-related symptoms caused hindrance in the work performance of the affected workers. The questionnaire was translated into the mother language in order to overcome the communication barrier and to get the maximum output from the workers. The questionnaires were filled out by the morning- and evening-shift workers. Data was collected during working hours with the assistance of managers. The body mass index was calculated as:

$$\text{BMI} = \text{weight [kg]/height [m}^2\text{]} \quad (1)$$

**Statistical analysis**

A statistical analysis was performed on the socio-demographic data and health problems due to cold environment, by means of statistical software. The means and standard deviations of the exposed and unexposed groups were taken into account. A one-way analysis of variance (ANOVA) and a t-test were applied for statistical differences and variations, using SPSS 16. The statistical difference at a significance level of $p < 0.05$ was considered.

## RESULTS

The study subjects were divided into 2 categories, i.e., the exposed and unexposed group. The average age of the exposed and unexposed workers was 27.16±5.859 and 32.32±8.665, respectively. According to the BMI data, 73% of the exposed workers were normal, 23% were overweight and 4% were obese. The demographic features of the exposed subjects are outlined in Table 1.

Out of 100 exposed subjects, the prevalence of finger symptoms showed that 60% felt cold sensation, 62% experienced numbness, 45% felt pain in their fingers, and 51% had finger stiffness. With respect to the frequency of changes in the color of finger tips, 40% of the exposed subjects showed white fingers, 65% blue fingers, and 80% red/purple fingers. Based on the skin problem frequencies, 50% of the exposed subjects experienced itching, 80% stiffness, 60% cracks/cold burns on the skin, 80% facial skin cooling, 83% changes in the color of their nose and cheeks, and 55% frostbite/frostnip. In the case of repeated musculoskeletal problems in the exposed group, 75% felt pain in the neck or shoulder region (the upper extremity), 68% reported back or hip pain, and 73% experienced pain in the lower extremities. Peripheral circulation disturbance was reported by 65% of the subjects, migraine-type headache by 83%, blurred vision by 50%, and disturbed circulation in the hands and feet by 70%. As regards the occurrence of respiratory symptoms associated with lung function impairment in the exposed group, 80% of the subjects reported the shortness of breath, 80% persistent coughing or bouts of coughing, 45% coughing that produces phlegm, 85% wheezing, and 76% increased mucus secretion. Decreased concentration and motivation occurred in 40% of the subjects each, while decreased manual strength and musculoskeletal function were reported by 80% each. The estimation of the relative risk (RR) and 95% confidence interval (CI) of cold-related subjective symptoms between the exposed and unexposed groups is depicted in Table 2.

A significant decline ($p < 0.01$) in the level of performance, on the basis of concentration and motivation, was reported between the exposed and unexposed groups. A highly significant difference ($p < 0.001$) was reported when a comparison was made between the exposed and unexposed groups in terms of the manual strength and musculoskeletal function.

**Table 1.** Demographic attributes of cold temperatures in the exposed (cold storage workers) and unexposed groups (control)

| Demographic | Exposed group | Unexposed group | p |
|---|---|---|---|
| Age [years] (M±SD) | 27.16±5.859 | 32.32±8.665 | 0.006 |
| Height [cm] (M±SD) | 169.55±6.754 | 166.98±3.353 | 0.000 |
| Weight [kg] (M±SD) | 66.33±11.101 | 76.44±5.756 | 0.052 |
| BMI [kg/m$^2$] (M±SD) | 23.261±2.885 | 27.45±2.341 | 0.171 |
| Exposure status [years] | 3.55±2.026 | 6.260±2.190 | 0.965 |
| Working frequency [days/month] (M±SD) | 27.15±1.827 | 23.260±2.337 | 0.082 |
| Working duration [h/day] (M±SD) | 8.90±1.604 | 8.180±1.149 | 0.752 |
| Smoked cigarettes [n] (M±SD) | 2.99±3.537 | 0.623±0.473 | 0.000 |

**Table 2.** Evaluation of the relative risk (RR) and confidence interval (CI) of the subjective symptoms due to cold in the exposed and unexposed groups

| Subjective symptoms | RR (95% CI) | p |
|---|---|---|
| Fingers symptoms | | |
| cold sensation | 30.00 (7.53–119.40) | 0.0001 |
| numbness | 125.00 (7.83–1993.27) | 0.001 |
| pain | 91.00 (5.68–1457.13) | 0.001 |
| stiffness | 103.00 (6.44–1646.35) | 0.001 |
| Fingers color variation | | |
| white | 81.00 (5.04–1299.44) | 0.001 |
| blue | 131.00 (8.21–2087.89) | 0.001 |
| red/purple | 40.00 (10.10–158.28) | 0.0001 |
| Skin problems or injuries | | |
| itching | 101.00 (6.31–1614.82) | 0.001 |
| stiffness | 14.54 (6.14–34.44) | 0.0001 |
| cracks or cold burns (hands/facial skin) | 121.00 (7.58–1930.20) | 0.001 |
| facial skin cooling | 14.54 (6.14–34.44) | 0.0001 |
| change in the skin color of the cheeks and nose | 167.00 (10.50–3655.59) | 0.001 |
| frostbite or frostnip | 111.00 (6.95–1772.51) | 0.001 |
| Repeated pain in the musculoskeletal system | | |
| neck/shoulder or upper extremity | 15.00 (6.33–35.51) | 0.0001 |
| back or hip pain | 137.00 (8.59–2182.51) | 0.001 |
| lower extremities | 7.30 (4.00–13.30) | 0.0001 |
| Peripheral circulation symptoms occurring episodically | | |
| disturbance in peripheral circulation | 131.00 (8.21–2087.89) | 0.001 |
| disturbed circulation in the hands and feet | 141.00 (8.85–2245.58) | 0.001 |
| blurred vision | 16.66 (5.37–51.67) | 0.0001 |
| migraine-type headache | 21.00 (6.82–64.65) | 0.0001 |
| Respiratory symptoms | | |
| shortness of breath | 18.18 (6.91–47.81) | 0.001 |
| persistent coughing or bouts of coughing | 161.00 (10.12–2560.97) | 0.003 |
| coughing that produces phlegm | 91.00 (5.68–1457.13) | 0.001 |
| wheezing | 7.08 (4.13–12.12) | 0.0001 |
| increased mucus secretion from the lungs | 153.00 (9.61–2434.82) | 0.004 |
| Decreased performance due to cold | | |
| concentration | 81.00 (6.91–47.81) | 0.001 |
| motivation | 81.00 (6.91–47.81) | 0.001 |
| manual strength | 14.54 (6.14–34.44) | 0.0001 |
| musculoskeletal function | 14.54 (6.14–34.44) | 0.0001 |

Significant difference – $p < 0.05$, more significant difference – $p < 0.01$, highly significant difference – $p < 0.001$.

**Table 3.** Evaluation of the relative risk (RR) and confidence interval (CI) of musculoskeletal symptoms in different body regions of the exposed and unexposed groups

| Body regions | RR (95% CI) | p |
|---|---|---|
| Neck | 15.00 (6.33–35.51) | 0.001 |
| Shoulders | 151.00 (9.48–2403.28) | 0.0004 |
| Elbows | 10.40 (4.33–2434.82) | 0.0001 |
| Wrists/hands | 23.33 (7.59–71.64) | 0.0001 |
| Upper back | 21.00 (6.82–64.65) | 0.0001 |
| Lower back | 4.11 (2.66–6.34) | 0.0003 |
| One or both hips/thighs | 111.00 (6.95–1772.51) | 0.001 |
| One or both knees | 6.87 (3.45–13.67) | 0.001 |
| One or both ankles/feet | 3.53 (2.13–5.83) | 0.001 |

Significant difference – $p < 0.05$, more significant difference – $p < 0.01$, highly significant difference – $p < 0.001$.

The estimation of the RR and 95% CI of cold-related musculoskeletal subjective symptoms between the exposed and unexposed groups is outlined in Table 3. The prevalence of symptoms in different body regions was one or both hips/thighs (55%), one or both knees (55%), one or both ankles/feet (53%), neck (75%), shoulders (75%), elbows (52%), wrists/hands (70%), upper back (63%), and lower back (74%). It was estimated that the cold exposed workers showed highly significant difference ($p < 0.001$) in the neck, hands/wrists and upper back, with the symptoms occurring more frequently in the exposed group than in the unexposed group.

## DISCUSSION

Cold conditions inside a cold storage facility may boost up the risk of health issues in workers due to continuous exposure during work [14]. Cold-related health problems increase with age, exposure duration and smoking [15]. It was found that the prevalence of cold sensations in the fingers and feet in the exposed subjects was higher, and there were more chances of cold-related health risks in the exposed group [16]. Discomfort, pain, stiffness and numbness in the hands were observed by the subjects when exposed to cold environment [17]. The wind speed, humidity, and cold temperature increased the skin sensitivity to cold, thereby leading to pain in the hands, feet, nose, ears and fingers. With low indoor temperatures, redness and swelling of the skin were likely to occur [18]. The degree of skin cooling was dependent on the temperature and contact surface time while touching any cold surface. So, longer exposure to cold causes skin itching [19]. There are more chances of circulatory disturbances that occur periodically due to improper protection of the hands and feet [20]. A dose-response relationship was found between working in a cold indoor environment and the risk of developing rheumatoid arthritis [21].

Major causes of musculoskeletal symptoms were workload and cold exposure. There are more chances of musculoskeletal complaints due to prolonged exposure to a cold environment. The low back pain and shoulder pain seem to accomplice with cold conditions [22]. The prevalence of upper limb symptoms was significantly higher among cold storage workers, compared to controls in the fish industry [23]. Among meat processing workers, pain symptoms in different body regions increased in the workers exposed to cold temperatures compared to unexposed workforce [24]. More cases of upper limb disorders were observed in the subjects working in cold temperatures [25]. The grip-span of workers showed significantly lower values while working in low temperatures, as compared to workers in normal temperatures [26]. In colder regions, the low back and neck pain symptoms were also observed in the subjects working outdoors in cold environments [27]. Although there are international standards for the assessment of cold-related hazards, no standards have been established to date as regards the problems associated with contacting cold surfaces [28]. People working in the frozen food industry should be encouraged to wear body protection [29].

## CONCLUSIONS

A cold indoor work environment involves several adverse health effects. Musculoskeletal symptoms, pain in different body regions, color change of fingertips, facial cooling, skin itching and stiffness occur more frequently. A longer and constant exposure to an extremely cold indoor environment can hinder the efficiency, performance and work ability of the exposed workers. Specific remedial measures should be adopted, which may include protective equipment, sufficient breaks, shuffling of workers and continuous medical examination. Personal protective equipment must be designed specifically, keeping in view the cold storage environment. The use of such equipment must be ensured by the government-approved competent authority in accordance with international laws. A continuous monitoring system must also be developed to ensure strict compliance.

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