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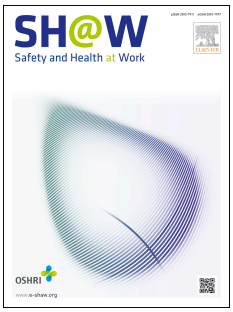


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# Cold Exposure and Health Effects among Frozen Food Processing Workers in the Eastern Thailand

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**Abstract**

This study explored factors affecting workers' health in the frozen food industry in Thailand. Subjects comprised 497 workers exposed to cold working environment, and 255 office workers who served as the controls.

Data were collected by a survey on the work environment, and the interview of workers for abnormal symptoms. The exposed group was 52.7 % male, with an overall average age of 27 (SD 6.6) years old, attained elementary (grade 4 and grade 6) (54.1%), were married (48.9 %), smokers (21.3 %), alcohol consumption (31.0 %), duration of work was between 1-5 years (65.2 %), working 6 days a week (82.7%), 1-5 hours of overtime per week (33.8%. ), office workers (33.9%), sizing (6.9%), peeling (28.3%) dissecting (22.2%), and warehouse (8.6%). The temperature in the work environment ranged from 17.2 to 19.2°C in most sections, -18.0 °C in the warehouse, and 25 °C in the office areas. Warehouse workers had more abnormal symptoms than controls included repeated pain in the musculoskeletal system (OR 11.9; 95% CI 6.12 - 23.45), disturbance throughout the body (OR 4.60; 95% CI 2.00 - 10.56), respiratory symptoms (OR 9.73 95% CI 3.53 - 26.80), episodic finger symptoms (OR 13.51; 95% CI 5.17 - 35.33).

The study results suggest that workers' health should be monitored especially back and muscle pain, respiratory symptoms, finger symptoms episodic, and cardiovascular symptoms. Health promotion campaign such as anti-smoking and reduction of alcohol consumption should be established because smoking and alcohol consumption are the contributing factors to the pathogenesis of Raynaud's phenomenon and peripheral vascular disorders such as hypertension and heart disease.

**Keywords:** cold, illness, health surveillance

**Introduction**

As one of the world's food production hub, Thailand is famous for frozen food industry. Seafood industry inevitably needs labor to work in many different sections like shrimp beheading, peeling, sizing, dissecting, and so on.

Frozen food processing workers have been exposed to potential health hazards including physical, biological, chemical, and psychosocial work environment [1, 2]. Low temperature is useful in the production of industrial frozen food, keeping the quality of fresh food last longer. However, it can be dangerous causing the body core temperature drops. Accompanied with wind speed and humidity levels, low temperature can affect workers' health [1, 3, 4, 5, 6, 7].

Although there has been no report on work related cold stress in Thailand [8], considering the threats of low temperature working environment and its impact on heath elsewhere [3, 4, 5, 6, 7, 8,9] we should pay attention to the impacts of it since there are a large number of warehouse workers whose jobs are located in low temperature work environment [9]. After exposure to low temperature, symptoms may not appear immediately. This period could distract us from considering low temperature as a cause of adverse health effects [3, 4, 9].

Low temperature working environment can cause various diseases [3, 4, 5, 6, 7,9] if there is no proper policy to control the adverse health effects from cold exposure occur in many organs such as respiratory system, musculoskeletal system (usually at temperature below 10 degrees [2], skin disorders such as rash and hives (Urticaria) [11], and cold-associated trauma such as Raynaud's phenomenon [12], frostbite, trench foot, chilblains and hypothermia.

It is evident that cold work environment can cause adverse health effects [1, 4, 5, 6, 10, 7, 9, 13] however, in Thailand, studies on cold exposure and health effects are limited. This study aims to explore the health effects of working in the cold environment and factors affecting abnormal symptoms of frozen food industrial workers to provide basic information to monitor health risks resulting from cold exposure.

## Materials and Methods

This is a cross-sectional study in which data were collected from April- September 2013.

### *Study population and subjects*

The study population was workers exposed to cold work environment who worked in 2 frozen food factories in Rayong Province, Thailand. The study subjects were calculated using the formula for

simple logistic regression analysis [14], where n was the sample size required, P was the rate of the event based on Lekcharoen et al. [15] who found that the proportion of workers who were exposed to cold frequently for more than 3 hours a day was 61.4% (P = 0.614) and $P_1 - P_2$ is the difference of the event between physical hazard exposed and non-exposed groups in which the minimum difference was 0.15.

Substituting the values in the formula and defined the error (α) of 5% (= 1.96) and the statistical power (1 - β) of 90% (= 1.28). The calculated sample size was 442.7 ≅ 443. Since this study explored many variables, therefore, the sample size [14] when $n_p$ was the adjusted sample size, and $n_1$ was the calculated sample size using the formula for simple logistic regression analysis. $R^2$ was the coefficient of multiple logistic regression, in which the study was set at 50% ($R^2$ = 0.50). The calculated sample size using the formula was 886 subjects.

All participants were permitted to decline or withdraw at any time from the study without penalty. Those who agreed to participate signed an informed consent form. The Institutional Review Board of Burapha University provided ethical approval for the study protocol.

**Tools and data collection**

***1. Interview***

Subjects were recruited to the study based on voluntary basis and informed consent was obtained from all subjects. The interview schedule consisted of 5 parts, *Part 1*: Socio-demographic characteristics such as gender, age, education, marital status, smoking and drinking history. *Part 2*: Current working history; number of working hours per day, number of working days per week, time to relax outside of work per day. *Part 3*: Health effects; cold exposure symptoms such as *repeated pain in the musculoskeletal system* (back pain and muscular pain), *symptoms throughout the body* (discomfort, shivering, itching after cold exposure, entire body cold), *respiratory symptoms* (asthma, respiratory wheezing, cough, excessive sputum, runny nose), *episodic finger symptoms* (darkening of fingers, redden of fingers, finger pain ,toe pain), *face and skin symptoms* (urticarial, face pain), *peripheral circulation symptoms* (blurry vision, headache, confusion), *cardiovascular system* ((pallor of fingers, chest pain, arrhythmia). The symptoms were rated by a score of 2 levels (0-1); 0=no

symptoms, 1= symptom. The interview schedule was verified by 2 occupational medicine physicians, and an occupational health specialist, then undergone a try out before use.

***2. Working environment data***

The secondary data of workplace temperature monitoring were used in this study. Real-time digital thermometer was used to monitor workplace temperature.

**Data analysis**

The statistical analysis package was used for data analysis. Socio-demographic characteristics, work history, and health effects were described in terms of percentages, means and standard deviations. Factors affecting health effects were analyzed using Logistic regression - backward elimination (p-remove = 0.10) to determine the relationships between age, gender, smoking, drinking, duration of work (years) and section with 7 abnormal symptoms: 1) repeated pain in the musculoskeletal system 2) symptoms throughout the body 3) respiratory symptoms 4) episodic finger symptoms 5) face and skin symptoms 6) peripheral circulation symptoms, 7) cardiovascular system.

**Results**

***1. Demographic characteristics***

Of the 886 subjects calculated as the sample size for this study, 752 (85%) were participated consisting of 497 exposed subjects and 255 controls who worked in the offices. Among the exposed group, 52.7% was male, 62.0% was 21-30 years old, 54.1 % attained elementary education, 48.9% was married, 21.3% was smokers with a mean smoking duration of 8.45 (SD 6.63) years, 31.4% was drinkers as shown in Table 1.

***2. Current work history***

Duration of work among the study subjects ranged from 0.08-22 years, with an average of 2.23 (2.70) years, working 8 hours a day or more. Majority (82.7%) worked 6 days per week. Average over time was 3.48 hours per week as shown in Table 2.

The temperature in the work environment of the study subjects ranged from 17.2 to 19.2°C in most sections, and -18.0 °C in the warehouse. Workers in sizing, peeling, dissecting, and warehouse sections were exposed to cold hazard and from the work environment, process water, and processing products. The temperature in the office areas was 25 °C.

***3. Health effects resulting from cold exposure***

The study subjects reported that they had abnormal symptoms, which included musculoskeletal system, discomfort, respiratory symptoms, finger symptoms episodic, face and skin symptoms, peripheral circulation symptoms, cardiovascular symptoms as shown in table 3.

***4. Factors affecting health effects***

Multiple logistic regression analysis revealed that factors affecting repeated pain in the musculoskeletal system were gender and work section. Being a female and working at sizing, peeling, dissecting, and warehouse sections were at higher risks of having back and muscle pain with the odds of 1.816 (95% CI: 1.186-2.781), 5.966 (95% CI: 3.045-11.691), 1.433 (95% CI: 0.866-2.371), 3.436 (95% CI:2.097-5.629), and 11.962 (95% CI:6.123-23.445) respectively.

Factors affecting symptoms throughout the body were gender and work section. Male and working in the warehouse were at higher risks of having symptoms throughout the body with the odds of 1.794 (95% CI: 1.219-2.641), and 4.597 (95% CI: 2.002-10.556) respectively.

Factors affecting respiratory symptoms were gender, smoking, and section. Female, smokers, and working in the warehouse were at higher risks of having respiratory symptoms with the odds of 1.888 (95% CI: 1.227-2.905), 1.607 (95% CI: 0.924-2.793), and 9.731 (95% CI: 3.534-26.797) respectively.

Factors affecting episodic finger symptoms were gender and work section. Female and working at the sizing and warehouse sections were at higher risks of having hand and finger disorders with the odds of 1.645 (95% CI: 1.119-2.419), 2.479 (95% CI: 1.113-5.438), and 13.514 (95% CI:5.169-35.327) respectively.

Factors affecting face and skin symptoms were gender, age, and section. Female, older worker, and working in the warehouse section were at higher risks of having face and skin symptoms with the odds of 1.932 (95% CI: 0.936-3.987), 3.509 (95% CI: 1.323-9.308) and 7.858 (95% CI: 3.171-19.471) respectively.

Factors affecting peripheral circulation symptoms were gender, and smoking. Female and smoker were at higher risks of having neurological disorders with the odds of 1.63 (95% CI: 1.045-2.541) and 1.949 (95% CI: 1.061-3.581) respectively.

Factors affecting cardiovascular system symptoms were gender, smoking, and work section. Female, smoker, working at the sizing and warehouse sections were at higher risks of having cardiovascular disorders with the odds of 1.717 (95% CI: 1.033-2.855), 2.147 (95% CI: 1.029-4.482), 2.516 (1.143-5.538), and 2.826 (95% CI: 1.275-6.264) respectively as shown in table 4.

**Discussion**

This study found that factors associated with back and muscular pain were gender. Female workers had more abnormal symptoms than male. Consistent with Nagasu M. et al.[16] who revealed that gender was associated with the prevalence of low back pain during 1 month work (Prevalence ratio, PR=1.32; 95% CI, 1.03 - 1.68) and consistent with Tomita S. et al. [17] who studied low back pain in migrant workers who worked in seafood production industry of Thailand. They found that female is consistent with low back pain (OR = 2.77, CI 95%: 0.79 - 9.75). Musculoskeletal disorders were related to working in the cold environment [9, 18].

This study found that age was not associated with low back and muscular pain. Apparently age was a risk factor of back pain, however; the subjects in this study were male, mostly around 21-30 years of age, without significantly degenerated spinal bone and intervertebral disc [19]. Moreover,

back pain was commonly found in adult workers. Low back pain prevalence was at peak around the ages of 40-69 in which female workers were at higher risk than male [20]. This was not consistent with previous studies which indicated that age was related to low back pain among Thai workers [21] and Western workers [22, 23]. Nevertheless follow-up studies in middle age and elderly workers should be conducted.

Sizing, peeling, dissecting and warehouse workers had more abnormal symptoms than the controls (OR = 5.966, 95% CI: 3.045-11.691; OR = 1.1816, 95% CI: 1.186-2.781; OR = 3.436, 95% CI: 2.097-5.629; OR = 11.962, 95% CI: 6.123-23.445) respectively. Due to different sections had different cold levels by which musculoskeletal system could be affected and at most in -10 degree Celsius environment [2]. Working in frozen food industries, workers who repeatedly exposed to cold, humidity, and repetition, was possibly faced muscle strain [23]. Harcombe H. et al.[25] also found that 70% (n=310) of workers had at least 1 musculoskeletal symptom (OR = 1.35, 95% CI: 1.14 to 1.6).

Factors affecting symptoms throughout the body were gender, age, and work section in which female had more abnormal symptoms than male (OR = 1.794, 95%CI: 1.2.19-2.641). Elderly workers reported more abnormal symptoms (OR = 0.934, 95% CI: 0.904-.964). Shivering was normally caused by cold exposure [26]. This study found that workers in extreme temperature (-18 degree Celsius) warehouse section had higher abnormal symptoms than the controls (OR = 4.597, 95%CI: 2.002-10.556) regardless of personal protective equipment provided. Physiologically body temperature regulation caused muscle strain and shivering [27, 28].

Cold exposure induced symptoms throughout the body such as discomfort which was gradually increased when temperature was below -10 degree Celsius [2] while itching did not occur [28] since below 20 degree Celsius of dermal temperature could reduce the symptom by 50%.

Factors affecting respiratory symptoms were gender, age, smoking, and work section. Female had more abnormal symptom than male (OR = 1.888, 95% CI: 1.227-2.905). Previous study indicated higher prevalence of asthma and bronchitis in female worker. Abnormal symptoms were

proportionally increased with age [30]. Smoking worker had more abnormal symptoms than non-smoker (OR = 1.607, 95% CI: 0.924-2.793) Smoking aggravated respiratory symptoms while working in the cold environment. Cold induced chronic diseases worse [2, 5, 13, 31] Moreover, smoking was the cause of Raynaud's phenomenon [12].

This study indicated that warehouse worker had more abnormal symptoms than the controls (OR = 9.731, 95% CI: 3.534-26.797). Cold and dry air inspiration caused acute and chronic symptoms of upper and lower respiratory tract. Higher morbidity and mortality in the winter [32] was indicated by 160,000 deaths in Michigan with chronic obstructive disease and at higher risk in colder days [33]. Respiratory disease among hard-working employees became worsen below -15 degree Celsius [34], however; differences in sensitivity of each and ventilation were associated with the symptoms [35].

Factors affecting episodic finger symptoms were gender, duration of work, and work section. Female workers had more abnormal symptoms than her counterparts (OR = 1.645, 95% CI: 1.119-2.419). Kaminski M. et al. [36] found that cold sensitivity of the fingers was the chief complaint among can manufacturing workers. Raynaud's phenomenon was mostly found among female workers with gangrenous fingers, toes, nose tip, earlobes, and nipples [37].

Warehouse workers had higher abnormal symptoms than the controls (OR = 13.514, 95% CI: 5.169-35.327). The temperature in the warehouse was normally lowest at -18 degree Celsius. Hassi [38], Holmér [4] found that wind speed, humidity, and cold temperature increased cooling rate of skin and tissues resulting in increasing sensitivity to cold, dermal vasoconstriction especially at the hands, feet, nose, and ears and musculo-skeletal pain at the fingers [2,31]. These abnormal symptoms occurred below -15 degree Celsius [34].

Factors affecting face and skin symptoms (urticaria) were gender, age, and work section. Female, older, and working in the warehouse had more abnormal symptoms (OR = 1.932, 95% CI: 0.936-3.987; OR = 3.509, 95% CI: 1.323-9.308; OR = 7.858, 95% CI: 3.171-19.471) respectively. With low enough temperature, urticaria, redden and swelled skin, could be occurred [11].

Factors affecting peripheral circulation symptoms were gender and smoking. Female and smokers had more abnormal symptoms (OR = 1.63, 95% CI: 1.045-2.541; OR = 1.949, 95% CI: 1.061-3.581) respectively. Bird N. et al. [39] indicated that cold induced migraine-like headache. The result of this study show that working in the warehouse section was not associated with peripheral circulation symptoms. Abdel-Hamid MA et al. [40] found that working in the office had higher incident of headache due to poor illumination, bad ventilation, noise, smoking, and dust.

Factors affecting cardiovascular system were gender, smoking, and work section. Female, smoking, working at sizing and in the warehouse had higher abnormal symptoms (OR = 1.717, 95% CI: 1.033-2.855; OR = 2.147, 95% CI: 1.029-4.482; OR = 2.516, 95%CI: 1.143-5.538; OR = 2.826, 95% CI: 1.275-6.264) respectively. Exposure to very low temperature would aggravate heart disease. Steven J. Swoap et al. [41] found those ambient air temperatures below 6 degree Celsius or over 29 degree Celsius resulting in changes in blood pressure and heart rate of mice. In clinical observation, cold exposure induced sympathetic activities causing higher risk of hypertension [43] (Rose G., 1961). Moreover, Kawahara J. et al. [43] reported that cold exposure possibly involved in abnormal heart-indicated parameters.

This study is limited by the relatively short duration of employment. Adverse health effects resulting from working in the cold environment have a long latency period. Moreover, the abnormal symptoms were reported by the subjects' perception. There was no medical evaluation by physicians.

It is suggested that workers' health should be monitored, especially back and muscle pain, respiratory symptoms, darkening of the fingers and toes, and disorders of the heart. As the cofactors of cold related diseases, those who work in the cold environment should avoid smoking and drinking to reduce the risk of cardiovascular disorders.

**Conflicts of interest:** All authors declare no conflicts of interest

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**References**

1 Jeebhay, M. F., Robins, T.G. World at work: Fish processing workers. Occup Environ Med 2004; 61(5):471 - 4.

2 Raatikka, V.P., Rytkönen, M., Näyhä, S., Hassi, J. Prevalence of cold – related complaints,symptoms and injuries in the general population: the FINRISK 2002 cold sub study. Int J Biometeorol 2007; 51(5): 441 - 8.

3 Hassi J, Raatikka V - P, Huurre M. Health - check questionnaire for subjects expose to cold. International Journal of Circumpolar Health 2003; 62(4): 436 - 43.

4 Holmér, I. Cold Indices and Standards. In: J.M. Stellman (ed) Encyclopaedia of occupational health and safety. Geneva: ILO; 1998. P. 4248 – 55.

5 Mercer, J. Cold – an underrated risk for health. Environmental Research 2003; 92: 8 - 13.

6 Mäkinen T.M., Rintamäki, H., Korpelainen, J.T., Kampmann, V., Pääkkönen, T., Oksa, J, Palinkas, L.A., Leppäluoto, J. ,Hassi, J. Postural sway during single and repeated cold exposures. Aviation, Space, and Environmental Medicine 2005; 76(10), 947 - 53.

7 Palinkas, L.A., Mäkinen, T.M., Pääkkönen, T., Rintamäki, H., Leppäluoto, J. , Hassi, J. Influence of seasonally - adjusted exposure to cold and darkness on cognitive performance in circumpolar residents. Scandinavian Journal of Psychology 2005; 46: 239.

8 Department of public Welfare. Ministry of Labour.[Internet]. Statistics in Workmen' s Compensation Fund. 2012 [cited 2014 July 1]. Available from http://www.sso.go.th/wpr/uploads/uploadImages/file/AnnualReportBook2555.pdf

9 Piedrahita H, Oksa J, Malm C and Rintamäki H. Health problems related to working in extreme cold conditions indoors. Int J Circumpolar Health 2008; 67(2- 3):279-87.

10 Tochihara, Y. Work in artificial cold environments. J Physiol Anthropol Appl Human Sci, Jan 2005; 24(1):73-6.

11 Lehmuskallio, E., Hassi, J., Kettunen, P. The skin in the cold. Int J Circumpolar Health 2002 ; 61(3): 277 - 86.

12 Roquelaure Y, Ha C, Le Manac'h AP, Bodin J, Bodere A, Bosseau C, Descatha A, Leclerc A,

Goldberg M, Imbernon E. Risk factors for Raynaud's phenomenon in the workforce. Arthritis Care Res (Hoboken) 2012; 64(6):898-904.

13 Hassi, J. Cold extremes and impact on health. In: Kirch W, Menne B, Bertollini R, editors. Extreme weather events and public health responses. Published on behalf of the WHO Regional office for Europe. Berlin, Heidelberg, New York: Springer – Verlag; 2005. p. 59 - 67.

14 Hsieh, F.Y., Bloch, D. A., and Larsen, M.D. A simple method of sample size calculation for linear and logistic regression. Statistics in Medicine 1998; 17:1623- 1634.

15 Nattakarn Lekchareon, Anamai Thetkathuek, Koolarb Rudtanasudjatum. Factors influencing health risk behaviors among Thai and migrant fishery workers in Kohperit, Lamseang, Chantaburi. The public health journal of Burapha University 2011; 1: 42-52.

16 Nagasu M, Sakai K, Ito A, Tomita S, Temmyo Y, Ueno M, Miyagi S. Prevalence and risk factors for low back pain among professional cooks working in school lunch services. BMC Public Health 2007; 24 (7): 171.

17 Tomita S, Arphorn S, Muto T, Koetkhlai K, Naing SS, Chaikittiporn C. Prevalence and risk factors of low back pain among Thai and Myanmar migrant seafood Processing factory workers in Samut Sakorn Province, Thailand. Ind Health 2010; 48(3): 283 - 91.

18 Pienimakí T. Cold exposure and musculoskeletal disorders and disease. A review. Int J Circumpolar Health 2002; 61: 173 - 82.

19 Thiese MS, Hegmann KT, Wood EM, Garg A, Moore JS, Kapellusch JM, Foster J, Greene T, Stoddard G, Biggs J; BackWords Study Team. Low-back pain ratings for lifetime, 1-month period, and point prevalences in a large occupational population. Hum Factors. 2014; 56(1):86-97.

20 D. Hoy, C. Bain, G. Williams et al. A systematic review of the global prevalence of low back pain. Arthritis Rheum 2012; 64: 2028 – 37.

21 Chaiwanichsiri D, Jiamworakul A, Jitapunkul S. Lumbar disc degeneration in Thai elderly: a population - based study. J Med Assoc Thai 2007; 90: 2477 – 81.

22 Miranda H, Viikari - Juntura E, Punnett L, Riihimäki H. Occupational loading, health behavior and sleep disturbance as predictors of low - back pain. Scand J Work Environ Health 2008; 34(6): 411 - 9.

23 Lötters F, Burdorf A, Kuiper J, Miedema H. Model for the work - relatedness of low - back pain. Scand J Work Environ Health 2003; 29(6): 431 - 40. Review.

24 Oksa J, Ducharme MB, Rintamaki. Combined effect of repetitive work and cold on muscle function and fatigue. J Appl Physiol 2002; 1: 356 - 61.

25 Harcombe H, McBride D, Derrett S, Gray A. Physical and psychosocial risk factors for musculoskeletal disorders in New Zealand nurses, postal workers and office workers. Inj Prev 2010; 16(2): 96 – 100.

26 Geng Q. Hand cooling, protection and performance in cold environment. Doctoral thesis, Luleå University of Technology; 2001.

27 Holmér I. Work in the cold. Review of methods for assessment of cold stress. International Archives of Occupational and Environmental Health 1993; 65: 147 - 55.

28 Holmér, I. Cold Indices and Standards. In: J.M. Stellman (ed) Encyclopaedia of occupational health and safety. Geneva: ILO; 1998. p. 4248 – 55.

29 Halkier - Sørensen L, Thestrup - Pedersen K. The relevance of low skin temperature inhibiting histamine - induced itch to the location of contact urticarial symptoms in the fish processing industry. Contact Dermatitis 1989; 21(3): 179 - 83.

30 Koskela H, Pihlajamäki J, Pekkarinen H, Tukiainen H. Effect of cold air on exercise capacity in COPD: increase or decrease?. Chest 1998; 113(6): 1560 - 5.

31 Hassi J, Juopperi K, Remes J, Näyhä S, Rintamäki H. Cold exposure and Cold related symptoms among Finns aged 25–64 years. In: ICHES - 98. Proceedings of Second International Conference on Human - Environment System. Yokohama; 1998. P. 271–4.

32 Näyhä S. Environmental temperature and mortality. International Journal of Circumpolar Health 2005; 64(5): 451 - 8.

33 Schwartz J. Who is sensitive to extremes of temperature?: a case - only analysis. Epidemiology 2005; 16: 67 - 72.

34 Giesbrecht G. The respiratory system in a cold environment. Aviation, Space, and .Environmental Medicine 1995; 66(9): 890 - 902.

35 Koskela HO. Cold air provoked respiratory symptoms. The mechanisms and management. International Journal of Circumpolar Health 2007; 66(2): 91 - 100.

36 Kaminski M, Bourgine M, Zins M, Touranchet A, Verger C. Risk factors for Raynaud's phenomenon among workers in poultry slaughterhouses and canning factories. Int J Epidemiol 1997; 26(2): 371 - 80.

37 Nicolas J, Labbé D. Rhytidectomy and Raynaud's phenomenon: about two cases. Ann Chir Plast Esthet 2004; 49(6): 564 - 8.

38 Hassi J. Cold extremes and impact on health. In: Kirch W, Menne B, Bertollini R, editors. Extreme weather events and public health responses. Published on behalf of the WHO Regional office for Europe. Berlin, Heidelberg, New York: Springer – Verlag 2005. P. 59 - 67.

39 Bird N, MacGregor EA, Wilkinson MI. Ice cream headache - site, duration, and relationship to migraine. Headache 1992; 32: 5.

40 Abdel-Hamid MA, A Hakim S, Elokda EE, Mostafa NS. Prevalence and risk factors of sick building syndrome among office workers. J Egypt Public Health Assoc 2013; 88:109-14.

41 Steven J. Swoap , J. Michael Overton , Graham Garber. Effect of ambient temperature on cardiovascular parameters in rats and mice: a comparative approach American Journal of Physiology - Regulatory, Integrative and Comparative Physiology 2004; 287(2):R391-6. Epub.

42 Rose G. Seasonal variation in blood pressure in man. Nature 1961; Jan 21: 189 –

235.

43 Kawahara J, Sano H, Fukuzaki H, Saito K, Hirouchi H. Acute effects of exposure to cold on blood pressure, platelet function and sympathetic nervous activity in humans. Am J Hypertens 1989; 2: 724 – 6.

**Table 1** Subject Characteristics

| Work sections | Non-exposed | Exposed | | | |
|---|---|---|---|---|---|
| | Office | Sizing | Peeling | Dissecting | Warehouse | Total |
| | n=255 (%) | n=52 (%) | n=213 (%) | n=167 (%) | n=65(%) | N=497 (%) |
| **Sex** | | | | | | |
| Male | 56 (22.0) | 29(55.8) | 98(46.0) | 83(49.7) | 52(80) | 262(52.7) |
| Female | 199(78.0) | 23(44.2) | 115(54.0) | 84(50.3) | 13(20) | 235(47.3) |
| **Age** | | | | | | |
| Mean (SD) years | **31.03 (6.78)** | **27.77(6.56)** | **27.5(6.60)** | **27(6.3)** | **30.11(6.99)** | **27.94 (6.66)** |
| Median (Max, Min) years | **30.00 (19-53)** | **27(19-48)** | **26(15-47)** | **26(18-50)** | **29(19-50)** | **27.00(15-50)** |
| **Education** | | | | | | |
| No education | 0(0.0) | 2(3.8) | 23(10.8) | 9(5.4) | 2(3.1) | 36(7.2) |
| Elementary (grade 4/6) | 9(3.6) | 28(53.8) | 112(52.6) | 118(73.3) | 11(16.9) | 269(54.1) |
| Junior /Senior high/ Diploma | 97(38.1) | 74(42.3) | 75(35.3) | 37(22.2) | 41(63.1) | 175(35.3) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Bachelor degree or higher | 149(58.4) | 0(0.0) | 3(1.4) | 3(1.8) | 11(16.9) | 17(3.4) |
| **Marital status** | | | | | | |
| Single | 149(58.4) | 21(40.4) | 96(45.1) | 70(41.9) | 37(56.9) | 224(45.1) |
| Married | 91(35.7) | 30(57.7) | 99(46.5) | 91(54.5) | 23(35.4) | 243(48.9) |
| Widow/ Divorce/ Separate | 15(6) | 1(1.9) | 18(8.4) | 6(3.6) | 5(7.7) | 30(6.0) |
| **Smoking history** | | | | | | |
| Current smoker | 20(7.8) | 14(26.9) | 41(19.2) | 36(21.6) | 32(49.6) | 106(21.3) |
| Non smoker | 235 (92.2) | 38(73.1) | 172 (80.8) | 131 (78.4) | 33 (50.8) | 371(74.6) |
| Mean (SD) (yr) | **8.20 (4.78)** | **6.08(3.32)** | **9.27(7.15)** | **8.30(6.23)** | **8.58(7.51)** | **8.45(6.63)** |
| Median (Max, Min) | **8 (2-18)** | **5(2-13)** | **6(1-29)** | **6(2-25)** | **7(1-26)** | **6(1-29)** |

**Table 2** Work history

| Factors | Non-exposed | Exposed | | | | Total |
|---|---|---|---|---|---|---|
| | Office | Sizing | Peeling | Dissecting | Warehouse | N=497 (%) |
| | n=255 (%) | n=52 (%) | n=213 (%) | n=167) (%) | n=65 (%) | |
| Work duration (yr) | | | | | | |
| < 1 | 48 (18.8) | 19(36.5) | 75(35.2) | 29(17.4) | 9(13.8) | 132(26.6) |
| 1 – 5 | 90(35.3) | 32(61.5) | 138(64.8) | 116(69.5) | 38(38.5) | 324(65.2) |
| > 5 | 117(45.9) | 1(1.9) | 0(0.0) | 22(13.2) | 18(27.7) | 41(8.2) |
| Mean (SD) | **3.47 (4.33)** | **1.31(1.32)** | **1.38(0.72)** | **2.65(2.23)** | **4.69(5.54)** | **2.23 (2.70)** |
| Median (Max, min) | **1.92 (0.08-24)** | **1.04(0.50-10)** | **1.25(0.08-4.67)** | **2(0.42-9)** | **2.17(0.08-22.67)** | **1.75(0.08-22.67)** |
| Work hour | | | | | | |
| < 8 | 0(0.0) | 0(0.0) | 1(0.5) | 0(0.0) | 1(1.5) | 2(0.4) |
| ≥ 8 | 255(100) | 52(100) | 212(99.5) | 167(100) | 31(100) | 295(99.6) |
| Mean (SD) | **8.20 (0.60)** | **8(0.0)** | **7.99(0.14)** | **8.01(0.07)** | **8.11(0.59)** | **8.01(0.237)** |
| Median (Max, | **8 (8-12)** | **8(8-8)** | **8(6-8)** | **8(8-9)** | **8(7-12)** | **8(6-12)** |

| | | | | | | |
|---|---|---|---|---|---|---|
| min) | | | | | | |
| Work days per week | | | | | | |
| 5 | 3(1.2) | 16(30.8) | 41(19.2) | 26(15.6) | 0(0.0) | 83(16.7) |
| 6 | 251(98.4) | 36(69.2) | 171(80.3) | 141(84.4) | 63(96.9) | 411(82.7) |
| 7 | 1(0.4) | 0(0.0) | 1(0.51) | 0(0.0) | 2(3.1) | 3(0.6) |
| Over time per week (hr) | | | | | | |
| 1 – 5 | 4(1.6) | 4(7.7) | 20(9.4) | 4(2.4) | 3(4.6) | 168(33.8) |
| 6 – 10 | 217(85.1) | 48(92.3) | 127(59.6) | 39(23.4) | 52(80) | 43(8.7) |
| > 10 | 34(13.3) | 0(0.0) | 66(31.0) | 124(74.3) | 10(15.4) | 2(0.4) |
| Mean (SD) | **1(0.0)** | **3.52(2.87)** | **3(2.58)** | **3.56(2.50)** | **5.21(3.85)** | **3.48(2.72)** |
| Median (Max, min) | **1(1-1)** | **3(1-12)** | **2(1-18)** | **2(1-10)** | **3(1-14)** | **2(1-18)** |

**Table 3** Health effects

| Symptoms | Non-exposed | Exposed | | | | |
|---|---|---|---|---|---|---|
| | Office | Sizing | Peeling | Dissecting | Warehouse | Total |
| | n=255 (%) | n=52 (%) | n=213 (%) | n=167 (%) | n=65 (%) | N=497 (%) |
| **Musculoskeletal system** (Back pain/Muscular pain**)** | | | | | | |
| No | 208(81.6) | 25(48.1) | 171(80.3) | 102(61.1) | 21(32.3) | 319(64.2) |
| Yes | 47(18.4) | 27(51.9) | 42(19.7) | 65(38.9) | 44(67.7) | 178(35.8) |
| **Symptoms throughout the body** (Discomfort Shivering/Itching after cold exposure/Entire body cold) | | | | | | |
| No | 38(39.6) | 28(57.1) | 145(68.1) | 62(37.6) | 12(18.8) | 247(50.3) |
| Yes | 58(60.4) | 21(42.9) | 68(31.9) | 103(62.4) | 52(81.3) | 244(49.7) |
| **Respiratory symptoms** (Asthma/Respiratory wheezing/Cough/Excessive sputum/ Runny nose) | | | | | | |
| No | 32(33.3) | 24(49.0) | 125(58.7) | 57(34.5) | 6(9.4) | 212(43.2) |
| Yes | 64(66.7) | 25(51.0) | 88(41.3) | 108(65.5) | 58(90.6) | 279(56.8) |

| Symptoms | Non-exposed | Exposed | | | | |
|---|---|---|---|---|---|---|
| | Office | Sizing | Peeling | Dissecting | Warehouse | Total |
| | n=255 (%) | n=52 (%) | n=213 (%) | n=167 (%) | n=65 (%) | N=497 (%) |
| **Finger symptoms episodic** (Darkening of fingers/Redden of fingers/Finger pain /Toe pain/Hands and legs sensitive to cold /Fingers and toes sensitive to cold) | | | | | | |
| No | 48(50.0) | 20(40.8) | 150(70.4) | 80(48.5) | 7(10.9) | 257(52.3) |
| Yes | 48(50.0) | 29(59.2) | 63(29.6) | 85(51.5) | 57(89.1) | 234(47.7) |
| **Face and skin symptoms** (Urticaria/ Face pain) | | | | | | |
| No | 70(72.9) | 47(95.9) | 199(93.4) | 157(95.2) | 28(43.8) | 431(87.8) |
| Yes | 26(27.1) | 2(4.1) | 14(6.6) | 8(4.8) | 36(56.3) | 60(12.2) |
| **Peripheral circulation symptoms** (Blurry/ vision /Headache Confusion ) | | | | | | |
| No | 47(49.0) | 24(49.0) | 15(70.9) | 135(81.8) | 33(51.6) | 243(69.9) |
| Yes | 49(51.0) | 25(51.0) | 62(29.1) | 30(18.2) | 31(48.4) | 148(30.1) |

| Symptoms | Non-exposed | Exposed | | | | |
|---|---|---|---|---|---|---|
| | Office | Sizing | Peeling | Dissecting | Warehouse | Total |
| | n=255 (%) | n=52 (%) | n=213 (%) | n=167 (%) | n=65 (%) | N=497 (%) |
| **Cardiovascular system** | | | | | | |
| (Pallor of fingers/Chest pain/ Arrhythmia) | | | | | | |
| No | 73(76.0) | 30(61.2) | 172(80.8) | 148(89.7) | 42(65.6) | 42(65.6) |
| Yes | 23(24.0) | 19(38.8) | 41(19.2) | 17(10.3) | 22(34.4) | 22(34.4) |

**Table 4** Factors affecting abnormal symptoms

| | Number | Musculoskeletal system | Symptoms throughout the body | Respiratory symptoms | Finger symptoms episodic | Face and skin | Peripheral circulation symptoms | Cardiovascular system |
|---|---|---|---|---|---|---|---|---|
| | | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) |
| **Sex** | | | | | | | | |
| Male | 318(42.3) | Ref | Ref | Ref | Ref | Ref | Ref | Ref |
| Female | 434(57.7) | 1.816 (1.186-2.781) | 1.794(1.219-2.641) | 1.888 (1.227-2.905) | 1.645(1.119-2.419) | 1.932 (0.936-3.987) | 1.63(1.045-2.541) | 1.717(1.033-2.855) |
| **Age (yr)** | 752 | - | 0.934(0.904-0.964) | 0.96(0.933-.988) | 0.951(0.92-0.982) | 3.509(1.323-9.308) | - | - |
| **Alcohol consumption** | | | | | | | | |
| yes | 227(30. | 0.69(0.448- | - | - | - | - | - | - |

**Table 4** Factors affecting abnormal symptoms

| | Number | Musculoskeletal system | Symptoms throughout the body | Respiratory symptoms | Finger symptoms episodic | Face and skin | Peripheral circulation symptoms | Cardiovascular system |
|---|---|---|---|---|---|---|---|---|
| | | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) |
| | 2) | 1.064) | | | | | | |
| No | 525(69.8) | Ref | | | | | | |
| **Smoke** | | | | | | | | |
| yes | 117(15.6) | | - | 1.607(0.924-2.793) | - | - | 1.949(1.061-3.581) | 2.147(1.029-4.482) |
| no | 567(75.4) | Ref | | Ref | | | Ref | Ref |
| **Duration of work (yr)** | 752 | - | 1.005(0.99-1.01) | - | 1.009(1.003-1.015) | 0.99(0.99-1.001) | - | - |
| **Work** | | | | | | | | |

**Table 4** Factors affecting abnormal symptoms

| | Number | Musculoskeletal system | Symptoms throughout the body | Respiratory symptoms | Finger symptoms episodic | Face and skin | Peripheral circulation symptoms | Cardiovascular system |
|---|---|---|---|---|---|---|---|---|
| | | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) | aOR (95%CI) |
| **section** | | | | | | | | |
| Office | 255(33.9) | Ref | Ref | Ref | Ref | Ref | Ref | Ref |
| Sizing | 52(6.9) | 5.966(3.045-11.691) | 0.638(0.291-1.395) | 0.66(0.31-1.404) | 2.479(1.13-5.438) | 0.11(0.024-0.51) | 1.339(.643-2.789) | 2.516(1.143-5.538) |
| Peeling | 213(28.3) | 1.433(0.866-2.371) | 0.417(0.23-0.756 ) | 0.487(0.277-0.856) | 0.742(0.41-1.349) | 0.025(0.095-0.44) | 0.571(0.332-0.983) | 1.026(0.552-1.907) |
| Dissecting | 167(22.2) | 3.436(2.097-5.629) | 1.336(0.74-2.415) | 1.242(0.688-2.242) | 1.503(0.843-2.68) | 0.144(0.06-0.346) | 0.272(0.15-0.494) | 0.433(0.212-0.888) |
| Warehouse | 65(8.6) | 11.962(6.123-23.445) | 4.597(2.002-10.556) | 9.731(3.534-26.797) | 13.514(5.169-35.327) | 7.858(3.171-19.471) | 1.596(0.775-3.287) | 2.826(1.275-6.264) |

**Note: -** Factors were removed from logistic model (p> 0.10)