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PREVALENCE OF HYPERTENSION AND ASSOCIATED OCCUPATIONAL FACTORS AMONG STEEL AND CERAMIC TILE WORKERS IN VIETNAM¹*National Institute of Occupational and Environmental Health, Hanoi, Vietnam;*²*Vietnam–Russia Tropical Center, Hanoi, Vietnam*

Hypertension is one of the most prevalent non-communicable diseases worldwide and a leading risk factor for cardiovascular morbidity and mortality. Industrial workers, particularly those exposed to unfavorable working conditions and high work intensity, may be at increased risk. However, evidence on hypertension among industrial workers operating under tropical hot and humid conditions remains limited.

We aimed to determine the prevalence of hypertension and analyze associated factors among steel workers and ceramic tile workers in Vietnam.

A cross-sectional descriptive study was conducted in 2022 among 1 228 production workers from two industrial enterprises, including 836 steel workers and 392 ceramic tile workers. Blood pressure was measured using a standardized protocol. Structured interviews were used to collect information on sociodemographic characteristics, working conditions, job stress, smoking, and alcohol consumption. Hypertension was defined according to Vietnamese Ministry of Health guidelines. Data were analyzed using descriptive statistics and binary analyses to estimate crude odds ratios (ORs) with 95% confidence intervals (95% CIs).

The overall prevalence of hypertension was 22,3%. Ceramic tile workers exhibited a higher prevalence of hypertension (39,8%) compared with steel workers (14,1%) ($p < 0.001$). Workers aged ≥ 35 years had a higher likelihood of hypertension than those aged < 35 years (OR = 2,2; 95% CI: 1,71–2,95). Similarly, workers with a working duration of ≥ 10 years were more likely to have hypertension than those with < 10 years of employment (OR = 3,6; 95% CI: 2,70–4,85). High proportions of workers reported smoking and harmful alcohol consumption in both occupational groups.

Conclusion. Hypertension represents an important occupational health problem among industrial workers in Vietnam, particularly among older workers and those with longer working duration, highlighting the potential role of prolonged exposure to unfavorable working conditions in tropical industrial settings.

Key words: *Hypertension; industrial workers; steel workers; ceramic tile workers; occupational health; tropical climate*

Introduction

Hypertension is one of the most common non-communicable diseases worldwide and represents a leading risk factor for cardiovascular diseases, stroke, and chronic kidney disease.

According to the World Health Organization, the number of adults living with hypertension has increased rapidly in recent decades, reaching more than 1.2 billion people globally, with the majority residing in low- and middle-income countries [1]. Hyperten-

sion does not only contribute significantly to premature mortality but also causes long-term impairment of health, reduces quality of life and work capacity, and places a substantial burden on healthcare systems and socio-economic development.

Recent epidemiological studies have reported that the prevalence of hypertension among Vietnamese adults ranges from approximately 20% to 30%, with higher rates observed among men, older age groups, and individuals

with unhealthy lifestyles such as smoking and harmful alcohol consumption [2, 3].

However, most studies on hypertension in Vietnam have primarily focused on the general population, while evidence among industrial workers remains limited. Industrial workers constitute a specific occupational group that is frequently exposed to multiple adverse factors related to working conditions, including high ambient temperatures, excessive noise, dust, chemical agents, high physical workload, shift work, and high workload and time pressure related to production targets. Prolonged exposure to these factors may lead to chronic physiological stress, imbalance of autonomic regulation, and an increased risk of cardiovascular disorders, including hypertension [4-6].

In heavy industries such as steel production and ceramic tile manufacturing, workers are often required to work in hot and humid environments, particularly in tropical countries like Vietnam. High environmental temperatures combined with high humidity may exacerbate heat stress, increase cardiovascular strain, and adversely affect blood pressure regulation. In addition, behavioral risk factors such as smoking and alcohol consumption are common among industrial workers, especially among male workers, further increasing the risk of hypertension and cardiovascular diseases [7-9].

International studies conducted among industrial workers in different countries have reported hypertension prevalence ranging from 15% to over 30%, depending on age, duration of employment, type of industry, and working conditions. These studies consistently demonstrate significant associations between hypertension and factors such as age, working duration, obesity, alcohol consumption, and occupational stress [10-12]. Nevertheless, differences in climatic conditions—particularly between temperate or cold regions and tropical hot and humid regions—may influence both the magnitude and characteristics of these associations.

In Vietnam, there remains a lack of comprehensive studies that simultaneously examine the prevalence of hypertension and its associated factors among different types of heavy

industrial workers under tropical hot and humid working conditions. This gap in evidence limits the capacity of occupational health services to design targeted screening, prevention, and intervention programs tailored to specific industries and working environments.

Therefore, the present study was conducted to describe the prevalence of hypertension and to analyze associated factors among steel workers and ceramic tile workers in Vietnam. By providing detailed data from a large occupational population working under tropical hot and humid conditions, this study aims to contribute scientific evidence to support occupational health management, preventive strategies, and policy development for industrial workers in Vietnam and in other countries with similar climatic and industrial characteristics.

Objective: To determine the prevalence of hypertension and analyze associated factors among steel workers and ceramic tile workers in Vietnam.

Materials and methods

Study design: This was a cross-sectional descriptive study, conducted to assess the prevalence of hypertension and associated factors among industrial workers.

Study setting: The study was carried out in 2022 at two industrial enterprises located in Vietnam, including one steel manufacturing enterprise and one ceramic tile manufacturing enterprise. These enterprises operate under tropical hot and humid climatic conditions, which are characteristic of most industrial regions in Vietnam.

Study population

Inclusion criteria: Workers were eligible to participate in the study if they met all of the following criteria: Directly involved in production activities at the enterprise; Having a working duration of at least six months at the time of the survey; Present at the workplace during the data collection period; Agreeing to participate voluntarily in the study after being informed about its objectives and procedures.

Exclusion criteria: Workers were excluded from the study if they met one or more of the

following conditions: Being on long-term sick leave, maternity leave, or other extended absence; Having acute medical conditions at the time of examination that could influence blood pressure measurements; Refusing to participate or failing to complete the required assessments.

Sample size and sampling method: A census sampling method was applied. All workers who met the inclusion criteria at the two selected enterprises were invited to participate in the study. A total of 1 228 workers participated fully, including 836 steel workers and 392 ceramic tile workers.

A total of 1,228 workers participated in the study, including 836 steel workers (68,1%) and 392 ceramic tile workers (31,9%). Among all participants, male workers accounted for 89,3%, while female workers accounted for 10,7%.

The mean age of the study population was $34,1 \pm 5,8$ years. The mean working duration was $7,6 \pm 4,3$ years. Ceramic tile workers were older and had longer working duration compared with steel workers. The sociodemographic and occupational characteristics of the studied workers, including age, sex, and working duration, are summarized in table 1.

Questionnaire survey: A structured questionnaire was used to collect information on sociodemographic characteristics (age, sex), occupational characteristics (type of work, working duration), perceived working conditions, job stress, and behavioral risk factors. The questionnaire was developed based on occupational health survey tools that have been previously applied in Vietnam and adapted to the study context [2].

Working conditions assessed included perceived exposure to high temperature, noise, dust, and chemical agents during the working

process. Job stress and work intensity were evaluated based on workers' self-reported perceptions of workload, work pressure, and work organization.

Assessment of behavioral risk factors: Information on smoking status, exposure to secondhand smoke, and alcohol consumption was collected through face-to-face interviews. Smoking status was classified as current smoker or non-smoker. Alcohol consumption was assessed by asking about drinking frequency and quantity. The amount of alcohol consumed was converted into standard drink units according to the recommendations of the World Health Organization [3]. Harmful alcohol consumption was defined based on the number of standard drinks consumed per drinking occasion.

Blood pressure measurement and classification of hypertension: Blood pressure was measured following a standardized protocol. Participants were instructed to rest for at least five minutes before measurement and to avoid smoking, alcohol, and caffeinated beverages for at least 30 minutes prior to the examination. Blood pressure was measured using calibrated sphygmomanometers with appropriate cuff sizes. Two measurements were taken for each participant, and the average value was used for analysis. Hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg, or current use of antihypertensive medication, in accordance with the Vietnamese Ministry of Health guideline on the diagnosis and treatment of hypertension (Decision No. 3192/QĐ-BYT, 2010) [2]. This guideline was used because it represents the official standard applied in occupational health practice in Vietnam during the study period.

Table 1 — General characteristics of the study population

Characteristics	Steel workers (n = 836)	Ceramic tile workers (n = 392)	Total (n = 1 228)
Sex			
Male	758 (90,7%)	338 (86,2%)	1 096 (89,3%)
Female	78 (9,3%)	54 (13,8%)	132 (10,7%)
Age (years, mean $\pm$ SD)	31,98 $\pm$ 4,05	38,48 $\pm$ 6,65	34,1 $\pm$ 5,8
Working duration (years, mean $\pm$ SD)	5,5 $\pm$ 1,66	11,9 $\pm$ 4,89	7,6 $\pm$ 4,3

Statistical analysis

Data were entered, cleaned, and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to describe the study population. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as means and standard deviations.

Associations between hypertension and related factors were examined using the chi-square (χ^2) test. Crude odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated to estimate the strength of associations between hypertension and selected factors. A p-value of less than 0,05 was considered statistically significant. The analysis focused on crude associations in order to provide an initial epidemiological assessment suitable for occupational health practice and workplace-based screening programs.

Ethical considerations: The study was conducted in accordance with ethical principles for medical research involving human subjects. Permission to conduct the study was obtained from the management of the participating enterprises. All participants were informed about the objectives and procedures of the study and provided voluntary consent prior to participation. Personal information was kept confidential and used solely for research purposes.

Results

Working conditions and job stress. Workers in both groups reported a high prevalence of adverse working conditions. Exposure to high temperature, noise, and dust was commonly reported among workers in both industries, particularly among steel workers. Exposure to chemical agents was also reported, with a higher proportion observed among steel

workers. Working conditions and occupational risk factors reported by workers in the two industrial groups are presented in table 2.

Regarding job stress, a large proportion of workers reported that their work required high intensity and was physically demanding. Although most workers perceived their work as being organized according to a clear plan, many still experienced considerable work pressure and stress.

Workers in both groups reported high levels of adverse working conditions, particularly heat exposure, noise, and dust. These factors appeared to be more frequently reported among steel workers. Exposure to chemical agents was also common, especially in the steel industry. High work intensity and job stress were widely reported in both groups.

Job stress and work organization. Most workers reported that their work was organized according to a plan and had a repetitive nature. However, despite the structured work organization, a high proportion of workers in both groups perceived their work intensity as high and stressful. Job-related stress characteristics assessed by self-report among the studied workers are presented in table 3.

Behavioral risk factors. Smoking and exposure to secondhand smoke were prevalent among workers in both groups. A considerable proportion of workers reported alcohol consumption at levels considered harmful, with many consuming more than three standard drinks per drinking occasion. Smoking and alcohol consumption patterns in the two occupational groups are presented in table 4.

Prevalence of hypertension. The overall prevalence of hypertension among the study population was 22,3% (95% CI 20,1-24,7). Hypertension prevalence was significantly higher among ceramic tile workers than steel workers (39,8% vs. 14,1%, $\chi^2=100,1$; $p < 0,001$).

Table 2 — Perceived working conditions among workers

Working conditions	Steel workers (n = 836)	Ceramic tile workers (n = 392)	χ^2 ; p-value
Exposure to high temperature	781 (93,4%)	321 (81,9%)	38,3; <0,001
Exposure to noise	764 (91,4%)	302 (77,0%)	48,3; <0,001
Exposure to dust	792 (94,7%)	318 (81,1%)	56,6; <0,001
Exposure to chemical agents	468 (56,0%)	146 (37,2%)	37,7; <0,001

Table 3 — Evaluation of job stress and work organization

Job stress factors	Steel workers (n = 836)	Ceramic tile workers (n = 392)
Work organized according to plan	689 (82,4%)	331 (84,4%)
Work repetitive	714 (85,4%)	352 (89,8%)
High work intensity	652 (78,0%)	308 (78,6%)
Work perceived as stressful	621 (74,3%)	296 (75,5%)

Factors associated with hypertension. Workers aged 35 years and older had a higher likelihood of hypertension compared with those younger than 35 years. Similarly, workers with a working duration of 10 years or more were more likely to have hypertension compared with those with shorter working duration. Crude odds ratios for hypertension according to age groups are shown in table 5. The relationship between working duration and hypertension, expressed as crude odds ratios, is presented in table 6.

Discussion

The strong association observed between longer working duration and hypertension may reflect the cumulative effect of prolonged exposure to adverse occupational factors rather than the influence of chronological age alone. From an occupational hygiene standpoint, this finding supports the need for differentiated preventive strategies and targeted health surveillance based on length of employment in industrial settings, emphasizing the importance of integrated and sustained preventive measures in industrial workplaces.

Although the present study did not quantify the independent effects of specific occupational exposures such as heat, noise, and dust,

Table 4 — Behavioral risk factors among workers

Behavioral risk factors	Steel workers (n = 836)	Ceramic tile workers (n = 392)
Current smoking	421 (50,4%)	184 (46,9%)
Exposure to secondhand smoke	589 (70,5%)	251 (64,0%)
Harmful alcohol consumption	368 (44,0%)	171 (43,6%)

these factors were highly prevalent among workers and may contribute to hypertension through chronic physiological stress mechanisms. Therefore, occupational conditions remain an important contextual factor in interpreting the observed associations.

Prevalence of hypertension among industrial workers. The overall prevalence of hypertension in the study population was 22,3%, which is comparable to estimates reported in community-based studies in Vietnam (approximately 20%–30%) [2-4]. A clear difference in hypertension prevalence was observed between the two occupational groups, with ceramic tile workers exhibiting a higher prevalence of hypertension (39,8%) compared with steel workers (14,1%) ($p < 0,001$).

This difference may be explained by the older age structure and longer working duration among ceramic tile workers, reflecting the combined effects of aging and cumulative occupational exposure. These findings are consistent with previous international studies among industrial workers, where hypertension prevalence typically ranges from 15% to over 30% depending on age structure, type of industry, and working conditions.

Association between age, working duration, and hypertension. The study findings

Table 5 — Association between age and hypertension

Age group	Hypertension (n, %)	No hypertension (n, %)	OR (crude)	95% CI	p-value
< 35 years	96 (14,1%)	583 (85,9%)	1,0	—	—
≥ 35 years	178 (32,4%)	371 (67,6%)	2,2	1,71–2,95	<0,001

Table 6 — Association between working duration and hypertension

Working duration	Hypertension (n, %)	No hypertension (n, %)	OR (crude)	95% CI	p-value
< 10 years	92 (12,7%)	634 (87,3%)	1,0	—	—
≥ 10 years	182 (34,0%)	320 (66,0%)	3,6	2,70–4,85	<0,001

demonstrate a significant association between age and hypertension, with workers aged 35 years and older being more likely to have hypertension compared with those younger. This result is consistent with numerous epidemiological studies indicating that increasing age is one of the strongest predictors of hypertension. Age-related changes in vascular structure and function, including reduced arterial elasticity and increased peripheral resistance, may contribute to elevated blood pressure with advancing age. In addition to age, working duration was strongly associated with hypertension. Workers with a working duration of 10 years or more had a markedly higher likelihood of hypertension than those with shorter employment duration [10,13]. This association suggests a cumulative effect of prolonged exposure to occupational stressors, adverse working conditions, and lifestyle-related risk factors over time. Similar findings have been reported in studies among industrial and occupational populations, where longer working duration was linked to an increased cardiovascular risk [6, 7].

Behavioral risk factors and hypertension. Behavioral risk factors, particularly smoking and harmful alcohol consumption, were highly prevalent among workers in both occupational groups. These behaviors are well-known contributors to the development and progression of hypertension. Nicotine exposure from smoking can lead to activation of the sympathetic nervous system, vasoconstriction, and increased heart rate, while excessive alcohol consumption has been associated with elevated blood pressure and impaired cardiovascular regulation [10, 11]. Although the present study did not perform multivariable adjustment, the high prevalence of these behavioral risk factors among workers with hypertension highlights the importance of addressing lifestyle-related determinants within occupational health programs. Workplace-based health promotion interventions focusing on smoking cessation and the reduction of harmful alcohol consumption may play a crucial role in the prevention and control of hypertension among industrial workers.

Working conditions, job stress, and hypertension. Adverse working conditions and high job stress were commonly reported among workers in both industries. Exposure to high temperature, noise, dust, and chemical agents was particularly prevalent among steel workers, reflecting the nature of heavy industrial production processes. High work intensity and perceived job stress were also widely reported in both occupational groups. Previous studies have suggested that chronic exposure to adverse working conditions and occupational stress may contribute to hypertension through sustained activation of stress-response mechanisms, including the hypothalamic–pituitary–adrenal axis and the autonomic nervous system [4,6,12]. In tropical hot and humid environments, heat stress may further exacerbate cardiovascular strain, potentially increasing the risk of hypertension. Although causal relationships cannot be established due to the cross-sectional design of the study, the findings highlight the need to consider both environmental and psychosocial factors in the prevention of hypertension among industrial workers [7,13].

Implications for occupational health practice. The results of this study have important implications for occupational health practice in Vietnam and other countries with similar climatic and industrial conditions. The high prevalence of hypertension, particularly among older workers and those with longer working duration, underscores the need for early screening and regular monitoring of blood pressure within occupational health surveillance systems.

In addition, comprehensive occupational health programs should integrate both medical surveillance and preventive interventions targeting modifiable risk factors, including lifestyle behaviors and working conditions. Improving the work environment, optimizing work organization, reducing excessive workload, and promoting healthy lifestyles may contribute substantially to reducing the burden of hypertension among industrial workers.

Study limitations

Several limitations of the study should be acknowledged. First, the cross-sectional

design does not allow for causal inference between exposure factors and hypertension. Second, information on working conditions, job stress, and behavioral factors was collected through self-reported questionnaires, which may be subject to recall bias. Third, the analysis was based on crude odds ratios, and potential confounding factors were not adjusted for in multivariable models.

Despite these limitations, the study has notable strengths, including a relatively large sample size, the inclusion of different types of heavy industrial workers, and a focus on a tropical hot and humid working environment, which remains underrepresented in occupational health research. Nevertheless, the study provides valuable applied evidence for occupational health practice due to its large sample size and emphasis on real working conditions in tropical industrial settings. The use of crude odds ratios reflects the applied occupational health perspective of the study and aims to provide practical evidence for workplace screening and preventive programs.

Conclusions

This study provides an overview of the prevalence of hypertension and associated factors among steel workers and ceramic tile workers in Vietnam. The findings indicate that hypertension is a common health problem among industrial workers, even within the working-age population, and that there are clear differences between occupational groups.

Age and working duration were identified as important factors associated with hypertension, reflecting the combined effects of biological aging and cumulative exposure to occupational conditions over time. In addition, behavioral risk factors such as smoking and harmful alcohol consumption were prevalent among workers, particularly among those with hypertension, highlighting the role of lifestyle-related determinants in occupational health.

The study results emphasize that hypertension prevention and control should be implemented early and systematically in industrial workplaces, with a focus not only on medical management but also on preventive strategies

addressing modifiable risk factors and working conditions. The findings support the inclusion of hypertension prevention and control as a priority component of occupational hygiene programs in heavy industries, particularly under tropical hot and humid working conditions.

Ethics in Research: This study was approved by the Ethical Review Committee of the Vietnamese Ministry of Health.

Conflict of Interest: The authors declare no conflicts of interest.

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РАСПРОСТРАНЁННОСТЬ АРТЕРИАЛЬНОЙ ГИПЕРТЕНЗИИ И СВЯЗАННЫХ С НЕЙ ПРОФЕССИОНАЛЬНЫХ ФАКТОРОВ СРЕДИ РАБОТНИКОВ МЕТАЛЛУРГИЧЕСКОЙ И КЕРАМИЧЕСКОЙ ПРОМЫШЛЕННОСТИ ВО ВЬЕТНАМЕ

Артериальная гипертензия относится к числу наиболее распространённых неинфекционных заболеваний и ведущим фактором риска сердечно-сосудистой заболеваемости и смертности. Работники промышленности, особенно в условиях воздействия неблагоприятных производственных факторов и высокой интенсивности труда, относятся к группе повышенного риска. В то же время данные о распространённости артериальной гипертензии среди промышленных рабочих, трудящихся в условиях тропического жаркого и влажного климата, остаются ограниченными.

Цель исследования — определить распространённость артериальной гипертензии и проанализировать факторы, ассоциированные с её развитием, у работников металлургической и керамической промышленности во Вьетнаме.

В 2022 г. проведено поперечное описательное исследование среди 1 228 производственных рабочих двух промышленных предприятий Вьетнама, включая 836 работников металлургической промышленности и 392 работников керамического производства. Артериальное давление измерялось по стандартизированному протоколу. Сбор информации о социально-демографических характеристиках, условиях труда, трудовом стрессе, курении и потреблении алкоголя осуществлялся методом структурированного опроса. Артериальная гипертензия определялась в соответствии с национальными клиническими рекомендациями Министерства здравоохранения Вьетнама. Анализ данных включал описательную статистику и расчёт нескорректированных отношений шансов (OR) с 95% доверительными интервалами (ДИ).

Общая распространённость артериальной гипертензии составила 22,3 процента. У работников керамического производства показатель был значительно выше, чем у металлургов. Вероятность гипертензии была выше у лиц в возрасте ≥ 35 лет (OR=2,2; 95% ДИ: 1,71–2,95) и при стаже работы ≥ 10 лет (OR=3,6; 95% ДИ: 2,70–4,85). Высокая распространённость курения и вредного потребления алкоголя отмечалась в обеих профессиональных группах.

Полученные данные свидетельствуют о значимости артериальной гипертензии как актуальной проблемы гигиены труда среди промышленных рабочих, особенно при длительном воздействии неблагоприятных производственных факторов в условиях тропического климата, что подчёркивает целесообразность систематического скрининга и профилактических мероприятий в рамках производственного медицинского наблюдения.

Ключевые слова: артериальная гипертензия; промышленные рабочие; условия труда; гигиена труда; тропический климат

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