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A Relative Importance Index Approach to On-Site Building Construction Workers' Perception of Occupational Hazards Assessment

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Abstract

Background: *The construction industry has a high percentage of work-related injuries and fatalities. Workers' perception of occupational hazards exposure can be a proactive management tool in knowing the state of construction site safety performance. This study assessed the hazard perceptions of on-site construction workers in Ghana.* **Methods:** *Using a structured questionnaire, data was collected from 197 construction workers at live building sites in the Ho Municipality. The data were analyzed using the Relative Importance Index (RII) approach.* **Results:** *The study revealed that on-site construction workers perceived ergonomic hazards as the most frequent, followed by physical, phycological, biological, and chemical hazards. Long working hours had the highest overall RII ranking, followed by bending or twisting back during task performance, manual lifting of objects or loads, scorching temperatures, and lengthy standing for prolonged periods. The importance level of the RII revealed that long working hours and bending or twisting back during task performance were perceived as the most severe hazards.* **Conclusions:** *Given the adverse health effects of working for long hours, the management of Ghanaian construction industries needs to reinforce the legislation on working hours to safeguard workers' occupational health. Safety professionals can use the study's findings to improve safety performance in the Ghanaian construction industry.*

1. Introduction

The construction industry has an unarguably high percentage of work-related injuries and fatalities and considered one of the most dangerous industries to work in [1-3]. A disproportionate number of injuries and accidents in the construction industry have been linked to employee's perception of hazards and their associated risk. Meng and Chan [4] found a significant positive effect of individual risk perception toward safety performance among construction workers in China and Hong Kong. Improved employees' safety perception among Ghanaian construction workers enhanced and sustained their awareness and commitment to organizational health and safety practices [5]. Assessing the hazard

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exposure perception of the construction workforce is a critical step in knowing about safety issues and enhancing safety management at construction sites [6-7].

The hazard perception assessment approach has been used to determine the most critical hazards causing accidents and to design decision-aid systems for the construction industry [8-9]. Currently, little is known about the predictive factors contributing to construction workers' occupational accidents and injuries in the Ghanaian construction industry [10]. Also, the country lacks a robust institutional framework and poor enforcement of health and safety policies governing construction activities [11]. Furthermore, proper accident investigation is limited to prevent the repetition of the same accident on-site [12]. Hazard perception assessment among construction workers can be a useful predictive tool for managing occupational health and safety in the Ghanaian construction industry. Employees' shared perceptions regarding occupational hazards in the workplace is a snapshot of the prevailing state of safety in an organization [13-14].

According to Fatonade and Allotey [15], most accidents and injuries in Ghanaian construction sites emanate from a failure to identify hazards. Given the tremendous mediating effect of hazard perception on the construction industry's health and safety, more attention must be paid to its influence on employees' workplace safety. Hence, knowledge about the hazards associated with construction activities is a necessary foundation upon which safety management systems can be built. Assessing the hazard exposure perception of the construction workforce may be a vital proactive accident management tool to enhance construction site safety management. The objective of this study is to determine the perceived frequency of exposure to hazards of building construction workers and use it as a determinant of potential risk. The findings of this study can be interpreted in the same way as the epidemiology of work-related injuries in the construction industry [8], where knowledge about the most frequent hazard of exposure can be used to prioritize preventive actions.

2. Methods

2.1 Study Area

The study was conducted in the Ho Municipality which has a human population of 180,420 and covers a total land area of 587 km^2 and located between latitudes 6°20″N and 6°55″N and longitudes 0°12′E and 0° 53′E [16]. The municipality shares boundaries with Adaklu and Agotime-Ziope Districts to the South, Ho West District to the North and West, and the Republic of Togo to the East. The construction market in the municipality continues to expand and is ranked as the fifth-biggest employer out of 21 industrial activities due to increased infrastructural needs of facilities, such as homes, shops, schools, hospitals, and office spaces. To cater for the demand in construction activities, there is a need for a healthy workforce hence the need to look into occupational exposure to hazards.

2.2 Questionnaire Design and Development

According to Carter and Smith [7], most construction hazards remain unrecognized regardless of project type and location. Jeelani et al. [6] study also mentioned that workers might not know what hazards to expect and look out for due to uncertainty and diversity across projects and situations. Therefore, potential hazards related to building construction were identified, adapted, and modified from these studies [2, 3]. The modification was necessary as different project types (e.g., high-rise, residential, and municipal projects) have different hazards. The characteristics of building construction activities in the study area were adequately considered in the selection of the questions.

The survey questionnaire was organized into demographic aspects and hazard perceptions based on the frequency of exposure. The demographic part of the questionnaire dealt with characteristics such as gender, age group, last level of formal education, job specialty, and experience in the construction industry. The most recognized classification of construction-related hazards is biological, chemical, physical, ergonomic, and psychological [17, 18]. Respondents were asked to rate their hazard perception based on the frequency of exposure to the selected indicators of recognized hazards during construction activities on a five-point Likert scale varying from "Never" (1 = not expected to occur but still possible), "Seldom" (2 = not likely to occur under normal circumstances), "Sometimes" (3 = possible or known to occur), "Frequently" (4 = common occurrence) and "Always" (5 = continual or repeated experience) for the current hostel facility project being undertaken in the second part of the questionnaire. The questionnaire was programmed into the KoBoCollect Android smartphone application and pretested at construction sites to build the confidence of the research assistants in using the electronic tool for the data collection.

2.3 Determination of Sample Size

The sample size was estimated using a formula developed by Yamane [19]. It was calculated as:

$$n = \frac{N}{1 + N(e)^2}$$

where n is the sample size, N is the population size, and e is the level of precision. Using a confidence level of 95%, a level of precision of 5% (0.05), and a population size (N) of 258, the sample size (n) of 156 was obtained. The total number of respondents in each of the study companies and those that participated were 80 (60), 61 (55), 60 (42), and 57 (40) for sites 1, 2, 3, and 4, respectively. The number of respondents interviewed were, however, increased to 197 respondents because site supervisors allowed for the face-to-face administering of questionnaires to workers who were not busy outside the agreed schedule. The respondents were drawn from the site's list of workers using a simple random sampling approach.

2.4 Sampling Procedure and Data Collection

Four (4) ongoing hostel construction facilities for a Higher Institution of Learning (HEI) in the municipality were chosen because they represented most of the typical construction activities, including building, steel fixing, plastering, tiling, painting, glazing, electrical and sanitary installations. Also, the construction sites had almost all the artisans involved in building construction at the site providing easy accessibility to the different specialties in the building construction industry. In addition, most of the workers were permanent staff, and the temporal staff had a short-term contract with the companies involved in the construction. The casual workers selected had worked alongside the permanent and temporal staff for at least three months and were considered to have had sufficient time to be accustomed to their coworkers and the safety climate of the construction sites, given the largely transient nature of the construction workforce. The site supervisors were informed and requested to brief the workers about the study objectives to facilitate the process of data collection after permission had been obtained from the companies to conduct the survey.

Data were collected from the on-site building construction workers in May 2022. The structured questionnaire was completed through face-to-face administering of the questionnaire with the help of research assistants. The direct administration of the questionnaire was employed due to the low literacy levels of most artisans in the construction industry in Ghana, particularly in the Ho Municipality [20, 21]. Therefore, the research assistants explained the content of the questionnaire in the Ewe local language, which is widely spoken in the municipality and adopted as the lingua franca to the respondents who could not to read and understand the English language. Oral informed consent was obtained from each participant before interviewing. A 100% completion of the questions with each participant was ensured through the mandatory response setting to the KoboToolbox.

2.5 Data Analysis

2.5.1 Relative Importance Index (RII)

The Relative Importance Index (RII) was used to prioritize the indicators in this study. The RII is one of the most reliable approaches for rating variables using a structured questionnaire on a Likert scale [22]. The RII approach has been used in previous studies to rank construction-related exposure to hazards [23]. The RII was calculated using the following equation:

$$\textit{Relative Importance Index } (RII) = \frac{\sum \omega}{A * N}$$

where ω is the weighting given to each factor by the respondent (ranging from 1 to 5 in this study), A is the highest weight (i.e., 5 in this study), and N is the total number of respondents (i.e., 197 in this study). The relative importance index ranges from 0 to 1, with the highest RII indicating the maximum hazard perception of exposure from construction-related activities. The RII of values have been classified into: High (H) ($0.8 \leq RI \leq 1$), High-Medium (H-M) ($0.6 \leq RI < 0.8$), Medium (M) ($0.4 \leq RI < 0.6$), Medium-Low (M-L) ($0.2 \leq RI < 0.4$), and Low (L) ($0 \leq RI < 0.2$) to determine the important levels of attributes assessed [24, 25].

3. Results

All the 197 participants were males, and most of them were masons (n=44; 22.34%), laborers (n=34; 17.26%), painters (n=26; 13.20%), carpenters (n=25; 12.69%), steel benders (n=19; 9.64%), electricians (n=16; 8.12%), plumbers (n=14; 7.11%), and tilers (n=9; 4.57%) (Table 1). Most participants were between the ages of 21 to 30 years, followed by ages 31 to 40 years, ages 41 to 50 years, ages 18 to 20 years, ages 51 to 60 years, and the least number of participants were above 60 years. Regarding work experience of participants were 25.38% (n=50) of the participants had been in construction work for more than 20 years, 24.87% (n=49) for 6-10 years, 19.80% (n=39) for 1-5 years, 16.24% (n=32) for 11-15 years, and 13.71% (n=27) for 16-20 years. Overall, the participants with more than 10 years of work experience were about 55 % (Table 1). Permanent workers formed the majority of the participants (n=91; 46.19%), followed by temporal (n=76; 38.58%) and casual (n=30; 15.23%) workers. In terms of educational levels, 44.16% (n=87) of the workers participants reported having completed Junior High School (JHS), 36.04% (n=71) attained secondary, technical, or vocational education, 9.14% (n=18) reported having completed tertiary education, 8.63% (n=17) had attained primary education, and 2.03% (n=4) reported below primary or no formal form of education.

Table 2 indicates that most of the participants reported having heard of occupational hazards before (n=161; 81.73%), with their major sources of information emanating from the workplace (n=141; 87.58%), colleagues (n=93; 57.76%), radio (n=43; 23.71%), television (n=33; 20.50%), posters/banners (n=13; 8.07%), and school (n=7; 4.35%). Access to Personal Protective Equipment (PPE) among the participants was high (n=173; 87.82%) with the frequency of use in the order of often (n=66; 33.50), sometimes (n=64; 32.49%), always (n=30; 15.23%), rarely (n=10; 5.08%), and never (n=3; 1.52%) (Table 2).

The category and overall ranking of RII and the level of importance of each of the factors considered under the five types of hazards in this study are presented in the supplementary material (ST1). Regarding physical hazards, extreme hot temperature, sand dust, elevated noise, cement dust, and sun burns-sun exposure/ultraviolet radiation had the highest RII and were perceived to be of High-Medium importance level of exposure to the participants. Exposure to insects at the workplace had the highest RII under the biological hazard category and was ranked as a High-Medium importance level. Most of the biological hazards were perceived to be of Medium-Low importance level. The factors with the highest RII for the category of chemical hazards were irritant and/or allergic contact dermatitis with cement, gases, vapors, fumes, dust, or mist from burning of waste materials, and gases, vapors, fumes, dust, or mist from using pesticides sprayed to control or eliminate foliage, respectively (ST1). The chemical hazards were generally perceived as of Medium and Medium-Low importance level. Bending or twisting back during the performance of a task had the highest RII for ergonomic hazards and a High importance level. The rest of the factors considered under ergonomic hazards had a

Table 1. Demographic characteristics of study participants.

Characteristics	**No.**	**%**
Job specialty		
Mason	44	22.34
Laborer	34	17.26
Painter	26	13.20
Carpenter	25	12.69
Steel Bender	19	9.64
Electrician	16	8.12
Plumber	14	7.11
Tiler	9	4.57
Trusses Installer	3	1.52
CCTV and alarm Installer	2	1.02
Concrete Mixer Operator	1	0.51
Glass worker	1	0.51
Store keeper	1	0.51
Scaffolder	1	0.51
Welder	1	0.51
Years of work experience		
1-5 years	39	19.80
6-10 years	49	24.87
11-15 years	32	16.24
16-20 years	27	13.71
Above 20 years	50	25.38
Age group of participants		
18-20	19	9.64
21-30	84	42.64
31-40	57	28.93
41-50	22	11.17
51-60	13	6.60
Above 60	2	1.02
Form of employment		
Permanent	91	46.19
Temporal	76	38.58
Casual	30	15.23
Highest educational level of participants		
Below primary	4	2.03
Primary	17	8.63
Junior High School	87	44.16
Secondary/Technical/Vocational High School	71	36.04
Tertiary	18	9.14

Table 2. Knowledge of occupational hazards and access to personal protective equipment.

Have you heard of occupational hazard before?	**No.**	**%**
Yes	161	81.73
No	36	18.27
Where did you hear of occupational hazard?		
Workplace	141	87.58
Colleagues	93	57.76
Radio	43	26.71
Television	33	20.50
Poster	13	8.07
School	7	4.35
Do you have access to personal protective equipment?		
Yes	173	87.82
No	24	12.18
How often do you use the PPE?		
Always	30	15.23
Often	66	33.50
Sometimes	64	32.49
Rarely	10	5.08
Never	3	1.52

relatively high RII, and all were perceived to be of High-Medium importance level except lengthy sitting for prolonged periods that recorded a relatively low RII and Medium importance level. The psychological hazard category had the highest RII for long working hours, which had High importance level, followed by tight schedule for work and excessive workload, with both recording a High-Medium importance level (ST1).

The RII ranking for the 10 topmost factors in descending order were: long working hours (0.837), bending or twisting back during the performance of the task (0.810), manual lifting of objects/loads (0.797), extreme hot temperature (0.780), lengthy standing for prolonged periods (0.771), work with neck bent and twisted (0.760), tight schedule for work (0.709), repetitive lifting of heavy things(0.706), forced to overreach for equipment, tools and instruments (0.697), and repetitive carrying of heavy things (0.687). Ergonomic hazards variables were the most dominant among the 10 topmost factors. The importance level of the factors considered was perceived to be Medium (n=21), Medium-Low (n=20), High-Medium (n=16), and High (n=2). Long working hours and bending or twisting back during the performance of tasks were the two attributes that had High importance level. None of the 59 factors evaluated fell under the Low importance level. The average RII of the five types of hazards analyzed in this study recorded the highest RII for ergonomic hazards (0.708), followed by physical hazards (0.498), psychological hazards (0.460), biological hazards (0.411), and chemical hazards (0.408) (Figure 1).

4. Discussion

In this study, long working hours as a construction hazard of high importance level is aligned with prior research in other countries [26-28]. In Ghana. Enshassi et al. [27] found long, 27 working hours [28] to have the highest overall RII ranking among 28 factors associated with job stressors in the Palestinian construction industry. Rezaeian et al.

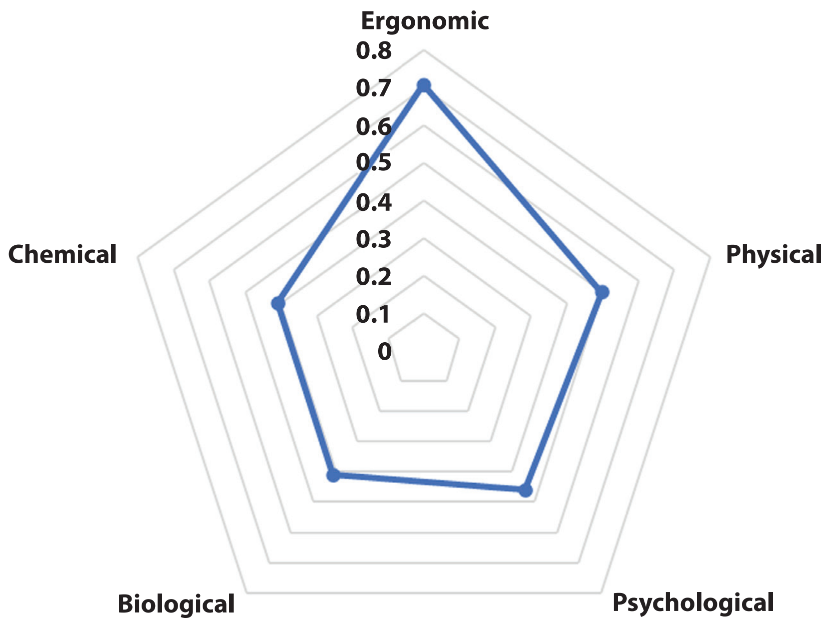

Figure 1. The average Relative Importance Index (RII) of the hazards assessed.

[26] found that most construction workers work long hours due to unachievable project completion deadlines in New South Wales (NSW), Australia. Long working hours were found by Ayarkwa et al. [28] to be the main barrier to the retention of females in the Ghanaian construction industry. Managers often use longer hours to cope with work overload and job demands [29]. The labor law of Ghana allows for voluntary overtime work, and workers may have been encouraged to take it due to the financial incentives leading to longer working hours. Otoo et al. [30] identified overtime pay to form a significant proportion of the income of Ghanaian workers. Tiwary et al. [31] made a similar observation for construction workers in India, where overtime pay encouraged long working hours among construction workers.

Excessive workload and tight schedules as the leading cause of psychological stress among construction workers are corroborated by previous studies [23, 27]. Indeed, Fordjour et al. [23] found tight deadline pressure and excessive workload to be first and second, respectively, in the overall RII ranking of 42 construction work-related psychological risk factors in Ghana. Rezaeian et al. [26] opined that most psychosocial problems in the construction industry result from unfeasible terms of project execution deadlines. In Ghana, delays in project execution have a critical effect on constructional budgetary allocation [32], and completing a project within the stipulated time frame is considered a critical factor for project success. Timely execution of projects to avoid the consequences associated with delays in completion by the construction firms may have influenced the long working hours, tight schedule for work, and excessive workload.

Construction, by its very nature, is physically demanding and requires, among other things, manual handling, bending and twisting, working in awkward or cramped positions, reaching away from the body and overhead, repetitive movements, and climbing and descending [33-35]. The physical nature is further aggravated by the pervasive labor-intensive approach in Ghana, where most of the work is conducted manually due to the low level of mechanization [33]. Manual material handling is considered one of the most physically demanding operations and a significant contributor to workers' exposure to ergonomic hazards [18, 34, 35]. Manual handling at construction sites offers a high risk of exposure to repetitive movements, forceful exertions, and awkward motions for extended durations, which are highly unsafe from an ergonomic viewpoint [35]. Manual material handling may account for this study's high-medium importance level of ergonomic factors, given the low reliance on machinery in the Ghanaian construction industry. The findings of this study are corroborated by other studies [33, 34] that also found manual handling as a significant contributor to ergonomic hazards among construction workers.

Construction workers are susceptible to heat stress because of hot weather, the physically demanding nature of work, and frequent, intense, and prolonged exposure to sunlight [36, 37]. Even within an indoor environment where workers are sheltered from direct sun exposure, the heavy workloads increase construction workers' risk of heat stress, particularly in the absence of mechanical ventilation [36]. Construction workers are at a high risk of heat stress-related disorders, including excessive sweating, dizziness, intense thirst, fatigue, dexterity, impaired concentration, visual acuity, and slippery palms secondary to sweating [36, 37]. The respondents in this study may have experienced the symptoms of heat stress due to their longer durations of exposure to higher temperatures, given the high RII for long working hours, which may account for the high RII of hot temperatures for physical hazard. Dust and noise were ranked 1st and 3rd as major environmental impacts of building construction activities in the Ho Municipality [24]. Their high RII under physical hazard reflects the environmental conditions in building construction sites. Non-adherence to Personal Protective Equipment (PPE) use by construction workers due to hot weather conditions [20] may have increased workers' exposure to dust and noise hazards.

Irritant and allergic contact dermatitis with cement as a major chemical hazard can be attributed to construction workers' non-adherence to using Personal Protective Equipment (PPE), especially protective clothing. In a previous survey, on-site construction workers were found to rarely use protective clothing because it makes them feel too hot during work [20]. Lissah et al. [38] identified the practice of open burning as an approach frequently used for waste management in the Ho Municipality. The burning of waste releases smoke and toxic fumes into the atmosphere. Construction workers may be exposed directly to the smoke and fumes, which can cause discomfort, such as breathing difficulties and eye irritation. The average cost of one-time manual weeding is higher than herbicide application per the same hectare in Ghana [39]. Common health symptoms such as headache, dizziness, catarrh, burning eyes, skin rashes, itching, and chest pain are associated with chemicals used to control vegetation [39]. The associated health implications of herbicide use may have influenced on-site construction workers' high perception of chemical hazard. Puddles of water at construction sites are prime breeding grounds for mosquitoes. The breeding of mosquitoes from stagnant water and other pests at construction sites was found by Ayarkwa et al. [40] to be a concern to construction practitioners because it affects employees' health. Ghana is considered an endemic malaria country, and the health implications associated with mosquito bites may have influenced on-site construction employees' perception as a biological hazard of high to medium importance level.

5. Conclusions

This paper focused on the hazard perception of exposure of on-site construction workers employing of quantitative analysis. The findings from the study revealed that on-site workers perceived ergonomic hazards as the most frequently encountered, followed by physical, psychological, biological, and chemical. Long working hours and bending or twisting back during the performance of tasks were the two attributes that were perceived to be of high recurrence and importance level at construction sites. Overall, the findings of this study highlight the hazard perception of exposure of construction workers as critical to assessing of potential risks in construction sites. This study revealed the need for promoting the integration of hazard perception of exposure by individuals into the health and safety of management practices in construction sites in the Ghanaian construction industry for improved safety performance.

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Appendix

Supplementary material (ST1). Relative Importance Index of hazards associated with construction activities.

Hazards	RII	RII Category Ranking	RII Overall Ranking	Importance level
Physical				
Extreme hot temperature	0.780	1	4	H-M
Sand dust	0.641	2	14	H-M
Elevated noise	0.638	3	15	H-M
Cement dust	0.626	4	16	H-M
Sun burns-sun exposure/ultraviolet radiation	0.607	5	17	H-M
Vibration	0.547	6	20	M
Extreme cold temperature	0.522	7	21	M
Slippery finish to the floor	0.477	8	24	M
Stepping on sharp objects (e. g., protruding nails)	0.474	9	25	M
Tripping, slipping, cuts, and falling	0.462	10	26	M
Inadequate ventilation	0.450	11	30	M
Inadequate lighting	0.445	12	32	M
Colliding with or being hit by sharp and/or protruding objects	0.425	13	34	M
Hit by a falling object	0.351	14	48	M-L
Hit by a moving object	0.350	15	49	M-L
Ultraviolet radiation from welding and cutting	0.340	16	51	M-L
Fall from height	0.324	17	52	M-L
Biological				
Exposure to insects at the workplace	0.648	1	13	H-M
Exposure to rodents at the workplace	0.459	2	27	M
Pricked by plants	0.459	2	27	M
Venomous animals and insects bite/sting at the workplace	0.442	3	33	M
Nonvenomous animal/insect bites/stings at the workplace	0.408	4	38	M
Fungi(mold)	0.385	5	42	M-L
Contact with the blood or body fluid of co-workers	0.380	6	44	M-L
Free-roaming dogs	0.356	7	47	M-L
Contact with co-workers diagnosed with communicable diseases	0.297	8	54	M-L
Being kicked or gored by an animal	0.276	9	55	M-L
Chemical				
Irritant and/or allergic contact dermatitis with cement	0.492	1	22	M
Gases, vapors, fumes, dust, or mist from the burning of waste materials	0.452	2	29	M
Gases, vapors, fumes, dust, or mist from using pesticides sprayed to control or eliminate foliage	0.413	3	35	M
Burns from chemicals	0.410	4	36	M

Table S1 (*Continued*)

Gases, vapors, fumes, dust, or mist from using adhesives and resins	0.409	5	37	M
Gases, vapors, fumes, dust, or mist from painting-particularly paint spraying	0.399	6	39	M-L
Gases, vapors, fumes, dust, or mist from using polish removers, paint removers, and paint thinners	0.382	7	43	M-L
Gases, vapors, fumes, dust, or mist from using oil from lubricants used in metal cutting operations	0.372	8	45	M-L
Gases, vapors, fumes, dust, or mist from welding and flame cutting	0.347	9	50	M-L
Ergonomic				
Bending or twisting back during the performance of a task	0.810	1	2	H
Manual lifting of objects/loads	0.797	2	3	H-M
Lengthy standing for prolonged periods	0.771	3	5	H-M
Work with neck bent and twisted	0.760	4	6	H-M
Repetitive lifting of heavy things	0.706	5	8	H-M
Forced to overreach for equipment, tools, and instruments	0.697	6	9	H-M
Repetitive carrying of heavy things	0.687	7	10	H-M
The awkward posture of the body	0.686	8	11	H-M
Repetitive pushing, pulling and moving of heavy things in wheelbarrow	0.677	9	12	H-M
Lengthy sitting for prolonged periods	0.485	10	23	M
Psychological				
Long working hours	0.837	1	1	H
Tight schedule for work	0.709	2	7	H-M
Excessive workload	0.605	3	18	H-M
Market risks and competition	0.588	4	19	M
Inadequate assistants/helpers	0.454	5	28	M
Isolation and lone working	0.448	6	31	M
Intimidation from colleagues	0.397	7	40	M-L
Tarnished reputation where you are accused of negligence	0.388	8	41	M-L
Verbal assaults from clients	0.365	9	46	M-L
Aggressive behavior from clients	0.365	9	46	M-L
Workplace bullying	0.315	10	53	M-L
Physical assaults from clients	0.276	11	55	M-L
Sexual harassment from clients	0.239	12	56	M-L

High (H) (0.8≤RI≤1), High-Medium (H-M) (0.6≤RI<0.8), Medium (M) (0.4≤RI<0.6), Medium-Low (M-L) (0.2≤RI<0.4), and Low (L) (0≤RI<0.2).