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RESEARCH PAPER

Occupational Risk Factors Assessment in Forging Sectors

Kavita Bhatt[1], Pragya Ojha[2] and Pankaj Kumar Ojha[3*]

[1]Department of Resource Management and Design Application, Lakshmibai College, University of Delhi, New Delhi, India
[2]Subject Matter Specialist, Krishi Vigyan Kendra Banda, Banda University of Agriculture and Technology, Banda (U.P.), India
[3]Department of Agriculture Extension, Banda University of Agriculture and Technology, Banda (U.P.), India

*Corresponding author: pankajojhabhu@gmail.com (**ORCID:** 0000-0002-8259-5639)

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ABSTRACT

Forge smiths, historically regarded as the most crucial and respected group in traditional rural settings, have been indispensable for the sustenance of agriculture and rural industries. Despite their paramount significance, these skilled workers face appalling working conditions characterized by the use of heavy tools and furnaces. Working in environments laden with heat, noise, vibration, and dust, forge smiths are particularly susceptible to various occupational health issues, leading to a higher incidence of sickness-related absenteeism. The study was carried out on a group of 120 individuals employed in the field of forging to determine the occupational hazards and various risk factors. Personal observation and interviews were conducted for workers involved in different activities of forging. ANOVA technique is applied to compare various activities and mean heart rate (during activity). The result was found to be significant at P<0.01, indicating average Heart rate and EER were significantly higher in case of group II who were engaged in striking operation in bending position i.e. 124.60 beats/min and 11.09 kJ/min, respectively as compared to other activity group workers. The result also revealed that forging workers were exposed to various occupational stressors and are at high risk of various work-related disorder that need to be taken care of through ergonomic intervention and medical treatment. It was concluded that by implementing various improvements, a safer and more conducive work environment for forging industry workers and be create.

HIGHLIGHTS

- Forge smiths experience high occupational risk due to prolonged exposure to heat, noise, vibration, dust, and physically demanding tasks.
- Striking operations performed in a bent posture produced the highest physiological workload (HR: 124.60 beats/min; EER: 11.09 kJ/min; $P < 0.01$).
- Ergonomic assessment identified significant work-related health hazards, increasing the likelihood of musculoskeletal disorders and occupational illnesses.
- Ergonomic interventions and improved workplace practices are essential to reduce physiological strain and enhance workers' health, safety, and productivity.

Keywords: Ergonomics, Mechanical Hazards, Biological Hazards, Health surveillance, Work Practices

In the realm of industrial production, the forging industry plays a pivotal role in shaping the manufacturing landscape of India. With its diverse applications in automotive, aerospace, construction, and other sectors, this unorganised sector i.e. forging contributes significantly to the country's economic growth. This sector is contributing not only to the economy of the country but is major portion of unorganized sector also. According to the Economic Survey for the year 2021-22, the unorganized sector had an approximate workforce of 43.99 crore individuals in the fiscal year 2019-20.

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However, behind the scenes of this crucial sector lies a hidden challenge i.e. occupational stress and associated risk factors due to high-risk environment with heavy machinery, extreme temperatures and hazardous material affecting the health of forging workers (Dinakaran & Rajan, 2025). Moreover, their compromised health is exacerbated by a range of socioeconomic factors, including poverty, limited access to education, adverse working conditions, excessive working hours, and inadequate dietary practices (Saha *et al.* 2010). Occupational stress is a prevalent issue that arises when there is an imbalance between job demands and the resources available to meet those demands. It is well-documented that the forging process is physically demanding, mentally taxing, and often fraught with time pressure. These factors, coupled with the repetitive nature of certain tasks and the need for precision, can create a high-stress work environment for the workers and also generate huge economic impact for many other associated companies (Si. *et al.* 2020). This study aimed to evaluate workplace hazards among forging workers in India and identify the worker group most vulnerable to these occupational risk factors, and determine the prevalence of these hazards. By gaining an in-depth understanding of these challenges, better and effective strategies to mitigate hazards can be developed and helps in improving the overall well-being of the workforce.

MATERIALS AND METHODS

Research Design and Study Area: The present study was a cross-sectional descriptive research design to investigate occupational stress and ergonomic risk factors among forging workers. The present study has been carried out in selected small scale forging units of Uttarakhand state of India. Most of the forging operations are carried out in unorganized sector with labour intensive methods of production.

Selection of Respondents: A total of 120 male forging workers were taken for the study. As there was no complete sampling frame available for workers working in unorganized forging sector, therefore snowball sampling technique was used to select the respondent. Initially, some workers were identified from selected forging units and then they referred others participants working in similar occupation. Male workers were only selected for the study as forging activities include hammering, striking and hot metal handling and are predominantly carried out by men in the chosen area. The inclusion criterion was at least one year of working experience, active participation in the forging related activities and voluntary consent to participate in the study.

Standardization of activities: Based on the preliminary survey conducted prior to the experiment, three activities in which the respondent's faced problems were selected. These activities include Hammering, striking, and cooling as shown in table 1.

Collection of data: After getting the consent, face to face interview was conducted at the workplace. Simultaneously workplace observation is carried out to access the ergonomic risk factors associated with each activities involved the forging work. Each participant was observed while performing hammering, striking, and cooling operations using the standardized checklist.

Statistical analysis of data: Appropriate statistical techniques, including ANOVA analysis, mean, percentage were used to analyse the data.

RESULTS AND DISCUSSION

Occupational History of Workers

The occupational profile of the respondents is shown in Table 2. The findings reveal significant differences in work experience and rest patterns among the three groups of forging workers. Overall, 35.83% of the respondents had 5 to 10 years of experience. Also, 31.66% had under 5 years and 25.83% had 10-15 years of experience. Those in hammering (Group I) had more experience. 60% of them had 10-15 years of experience. On the other hand, cooling workers (Group III) had under 5 years of experience. 62.5% of them had less than 5 years of experience, indicating a higher turnover for that area of work. Group III workers had at most 10 years of experience, most likely because of the strenuous nature of cooling work and the low pay. Their resting habits were also different. About two-fifths (38.33%) of respondents rested for 10 to 15 minutes, and 35.83% rested for 15 to 20 minutes. Workers in cooling operations had longer breaks. Of them, 77.5% rested for over 20 minutes, likely due to the need to recuperate from heat exposure.

Table 1: Occupational Details of Forge Smith's

Occupational details	Group I (Hammering)	Group II (Striking)	Group III (Cooling)
Activity			
Tools used			
Position adopted	Sitting	Bending	Squatting
Duration of task	Long	Long	Medium

**Note*: Duration: short(<1 hrs), medium (2-3 hrs), long (>4hrs).*

Table 2: Occupational Details of forge smiths

Working duration	Group I (n=40)	Group II (n=40)	Group III (n=40)	Total (N=120)
<5 years	2 (5)	11 (27.5)	25 (62.5)	38 (31.6)
5-10 years	8 (20)	20 (50)	15 (37.5)	43 (35.83)
10-15 years	24 (60)	7 (17.5)	—	31 (25.83)
>15 years	6 (15)	2 (5)	—	8 (6.66)
Resting period (min)				
10-15	26 (65)	18 (45)	2 (5)	46 (38.33)
15-20	14 (35)	22 (55)	7 (17.5)	43 (35.83)
>20	—	—	31 (77.5)	31 (25.83)
Resting frequency				
1-3 times	36 (90)	27 (67.5)	21 (52.5)	84 (70)
>3 times	4 (10)	13 (32.5)	19 (47.5)	36 (30)

When considering the frequency of breaks, 70% of the workers rested 1 to 3 times a day and 30% more frequently. Hammering workers had the longest work hours and rested the least. 90% of them rested 1 to 3 times a day.

These findings indicate that forging workers face long work hours with insufficient recovery periods, especially among hammering and striking workers. This increases their risk of physical exhaustion and occupational stress.

1. Occupational hazards, accidents, risks or injury at workplace

Forging is among the top five causes of injury in the manufacturing metal products industry. Hazards, accidents, risks or injuries are common incidence at forging work, as human factor engineering is the most ignored aspect of forging sectors (Nagarela *et al.* 2016). The research report had revealed that cent percent of workers were experiencing hazards or accident in their work places. The reason for these hazards or accidents includes awkward posture, allergies, rashes, itching, poor environmental condition etc.

Table 3 shows the hazards faced by forging workers over the past year. Every respondent (100%) reported experiencing at least one work-related hazard or accident, highlighting the dangers involved in forging.

1.1 Mechanical hazards

Mechanical hazards were the most common type of occupational risk reported. Nearly 96% of respondents dealt with awkward working postures, and 90% experienced repetitive tasks. More than half (57.5%) faced forceful exertion while working. The rate of awkward postures was particularly high among hammering and striking workers; all reported working in non-neutral positions. All striking workers reported forceful movements due to the continuous application of high-impact force during metal shaping. Cooling workers faced fewer forceful movements but reported awkward postures from prolonged squatting. The high prevalence of repetitive movements and awkward postures shows that ergonomic risks are the main hazards in forging work.

1.2 Biological hazards

Biological hazards are known as living or dead biological material that may have harmful effect on environment or human (Corrao *et al.* 2012). Though biological hazards were reported less often than

Table 3: Occupational hazards, accidents, risks or injury at work place (since last 1 year) (*N*=120)

Are you facing any kind of hazards or accident in your work place?		Group I	Group II	Group III	Total
		40 (100)	40 (100)	40 (100)	120 (100)

Sl. No.	Type of hazards	Reasons of hazard	No of workers			
			Group I	Group II	Group III	
1	Mechanical/ ergonomically	Repetitive task	38 (95)	37 (92.5)	33 (82.5)	108 (90)
		Awkward posture	40 (100)	40 (100)	35 (87.5)	115 (95.83)
		Sharpe edges	12 (30)	8 (20)	17 (42.5)	37 (30.83)
		Forceful motion	29 (72.5)	40 (100)	—	69 (57.50)
		Awkward grip	10 (25)	14 (35)	18 (45)	42 (35)
2	Biological	Rashes/ allergy	21 (52.5)	14 (35)	24 (60)	59 (49.16)
		Skin infection	14 (35)	—	22 (55)	36 (30.00)
		Itching	30 (75)	14 (35)	34 (85)	78 (65.00)
3	Chemical	Dust	30 (75)	22 (55)	32 (80)	84 (70.00)
		Smoke/fumes/gas	37 (92.5)	16 (40)	40 (100)	93 (77.50)
		Oil and solvents	—	—	13 (32.5)	13 (10.83)
4	Physical	Lifting	29 (72.5)	35 (87.5)	—	64 (53.33)
		Heat	36 (90)	6 (15)	35 (87.5)	77 (64.16)
		Tiring position	33 (82.5)	40 (100)	10 (25)	83 (69.16)
5	Environmental	Temperature	40 (100)	14 (35)	30 (75)	84 (70)
		Humidity	19 (47.5)	12 (30)	32 (80)	63 (52.5)
		Noise	40 (100)	40 (100)	32 (80)	112 (93.33)
		Light	21 (52.5)	10 (25)	—	31 (25.83)

**Figures in parentheses indicate the percentage values.*

mechanical hazards but remain important concerns. Itching affected 65% of workers, followed by rashes or allergies at 49.16%, and skin infections at 30%. Cooling workers had the highest rates of itching (85%) and skin infections (55%). Ongoing contact with stagnant cooling water and poor hygiene may have increased their exposure to germs. Hammering workers also reported significant itching (75%), likely due to use of untreated and unfiltered water that is stored in open containers for prolonged period.

1.3 Chemical hazards

Chemical exposure was common among respondents. More than three-fourths (77.5%) reported contact with smoke, fumes, and gases, while 70% faced dust exposure. Workers in cooling operations showed the highest exposure to smoke and fumes (100%) due to the rapid quenching of heated metals, which created thick vapours. The finding was supported by (Pandit & Patil, 2019) finding that various health hazards are observed in persons who are regularly exposed to different kinds of pollutants e.g. dust, fume, gaseous pollutants, noise, heat in forges.

Dust exposure was also highest among cooling (80%) and hammering (75%) workers. Only cooling workers reported exposure to oils and solvents (32.5%), reflecting differences in their job functions.

These findings indicate poor ventilation and weak engineering controls in forging units.

1.4 Physical hazards

Physical hazards are a combination of hazards from lifting, tiring position, heat and may lead to Muscular Disorder. Such muscular disorder occurs in almost every small-scale industry and workers are subjected to high risk of MSD (Singh *et al.* 2013). Physical hazards included prolonged tiring postures affecting 69.16% of respondents, heat exposure at 64.16%, and manual lifting at 53.33%. All striking workers reported tiring postures, while heat exposure was most common among hammering (90%) and cooling workers (87.5%). Manual handling of heavy tools and forged items was especially common among striking workers (87.5%), indicating significant physical strain during work.

1.5 Environmental hazards

Environmental hazards were widespread in forging activities. Excessive noise was reported by 93.33% of respondents, making it the most prevalent environmental hazard, followed by high temperatures at 70% and humidity at 52.5%. The result was in the line with the finding of (Lindstrom *et al.* 1984) who reported that disturbance in work performance due to noise was greater especially when estimated noise level was higher.

Noise exposure affected all hammering and striking workers due to constant impacts between metal surfaces and heavy hammers. Hammering workers reported the highest heat exposure (100%), while humidity was most frequently documented during cooling operations (80%).

Overall, the findings show that forging workers face multiple ergonomic, environmental, and chemical hazards, increasing their overall occupational risk.

2. Health surveillance of workers

The health surveillance findings are presented in Table 4.

About 73.33% of workers first noticed health problems while doing their job. This shows that workplace exposures were the main cause of health complaints. While 76.66% reported getting medical treatment, most (60%) used self-medication instead of seeking professional healthcare. Only 16.66% went to healthcare facilities, which suggests that access to occupational health services is poor and usage is limited. The most commonly reported health issues needing treatment were cuts and wounds (55%), body ache (54.16%), and backache (54.16%). Hammering workers had the highest rate of cuts and wounds (85%), while body ache was more common among striking workers (75%). Eye irritation was mainly reported by cooling workers (50%), likely due to continuous exposure to hot vapours and steam during quenching operations. Even after seeking treatment, only 26.66% of workers said they noticed improvement in their symptoms. This indicates that current treatment methods may not be effective for managing chronic occupational health problems.

Table 4: Health surveillance of workers

Question	Group I (n=40)	Group II (n=40)	Group III (n=40)	Total (N=120)
First notice the problem				
◆ Before working	—	10 (25)	5 (12.5)	15 (12.5)
◆ While working	40 (100)	28 (70)	20 (50)	88 (73.33)
You take the medical treatment	40 (100)	30 (75)	22 (55)	92 (76.66)
Take the treatment from				
◆ Personal doctor	—	—	—	—
Self	30 (75)	22 (55)	20 (50)	72 (60)
Others	10 (25)	8 (20)	2 (5)	20 (16.66)
Take the treatment for				
Headache	20 (50)	10 (25)	10 (25)	40 (33.33)
Body ache	32 (80) —	30 (75) —	3 (7.5)	65 (54.16)
Irritation on eyes	—	—	20 (50)	16 (13.33)
Stiffness in hand joints	—	—	—	—
Burning sensation in fingers	—	—	—	—
Pain in palm	10 (25)	10 (25)	—	20 (16.66)
Numbness in fingers	—	10 (25)		10 (8.33)
Cuts and wounds	34 (85)	20 (50)	12 (30)	66 (55)
Fractures	—	—	—	—
Cough/cold	10 (25)	—	16 (40)	26 (21.66)
Pain in trunk	—	—	—	—
Back ache	30 (75)	25 (62.5)	10 (25)	65 (54.16)
Shoulder pain	—	16 (40)	—	16 (13.33)
Did the treatment help?	10 (25)	12 (30)	10 (25)	32 (26.66)

**Figures in parentheses indicate the percentage values.*

3.1. Physiological cost of work of worker in term of Heart Rate (beats/minute)

The result of experiments conducted on various worker (as per activity profile) were analysed and presented in Fig. 1 for mean HR and per cent increase in Herat rate from its resting level. Work performance leads to an increase in the Heart Rate. The mean resting heart rate ranged as 82 to 85 beats/minutes for various activities. The variations of such responses for different activities are described in succeeding section.

- **In group I:** it was found that mean Heart Rate was 82.3 beats/minute at resting level, which reached to 120.6 beats/minute during work with percent increase of 15.43.
- **In group II:** the mean Heart Rate at resting level was 82.5 beats/minute, which increased up to 124.6 beats/minute during performance. Whereas, percent increase in Heart Rate was found to be 18.66, which was maximum in case of group II workers, when all group were compared.
- **In group III**: the mean HR before work, during work and recovery period was 84.5, 114.4 and 94.2 beats/minute, respectively and per cent increase in Heart Rate was 11.47.

3.2 Physiological cost of work of worker in term of Energy Expenditure Rate

According to the Fig. 2, the mean Energy Expenditure Rate (EER) kJ/min and increase in EER from its resting level for various types of activities performed by selected forging workers it was found that

- In group I (hammering), EER at resting, work and recovery period was 4.36, 10.45 and 6.38 (kJ/min), respectively with percent increase of 46.97.

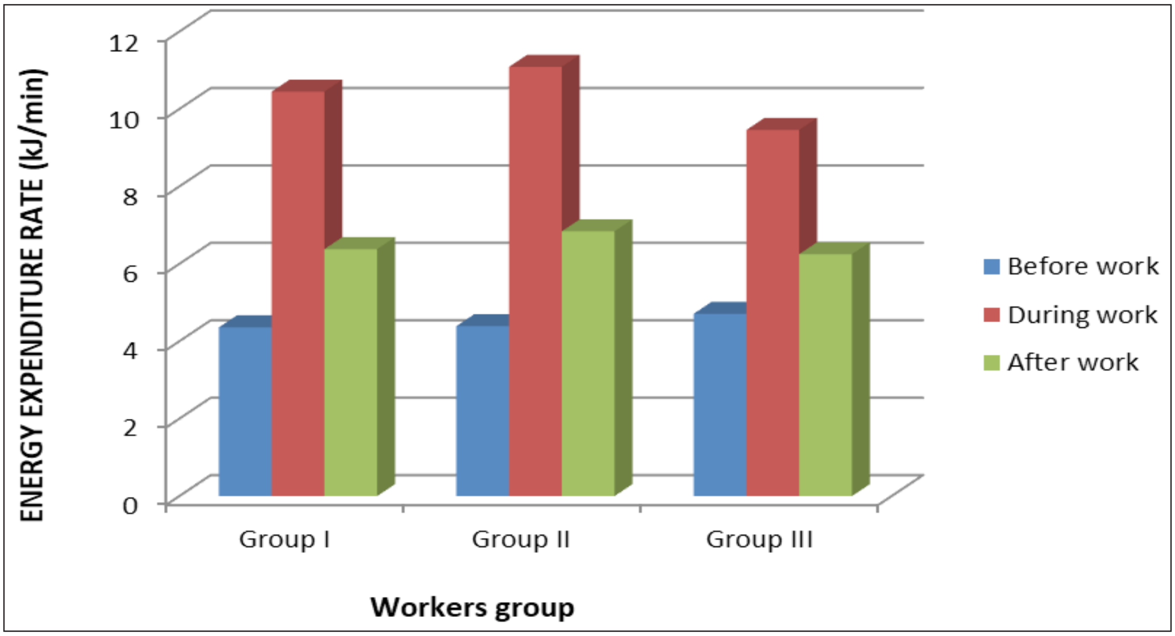

Fig. 1: Physiological cost of work of workers in term of Heart Rate (beats/minute)

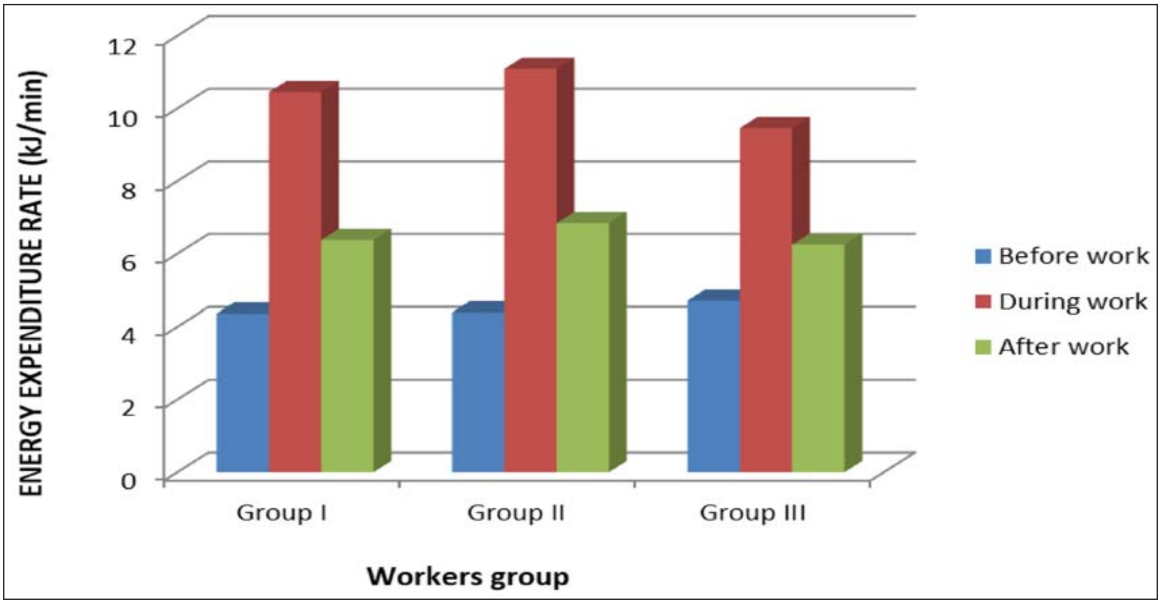

Fig. 2: Physiological cost of work of workers in term of Energy Expenditure Rate (kJ/min)

Table 5: Analysis of variance for HR and EER

Activities	Mean H.R. (During Work)	F value	Mean E.E.R (During Work)	F value
Group I (n=10)	120.6	9.03*	10.45	9.03*
Group II (n=10)	124.6		11.09	
Group III (n=10)	114.4		9.46	
	SEM=1.71		SEM=.27	
	C.D. 1%=6.96		C.D. 1%=1.10	
	C.V.=4.51		C.V.=8.31	

Significant at 1% Level of significance.

- For group II (striking), the Energy Expenditure Rate before work was 4.39 kJ/min which increased up to 11.09 kJ/min (during work), with per cent increase of 56.80.
- In case of group III (cooling), per cent increase in EER found to be 32.69, ranging from 4.71 (before work) to 9.46 (during work).

ANOVA technique is applied to compare various activities and mean heart rate (during activity). The result of ANOVA technique is presented in Table 5 the result was found to be significant at $P<0.01$, indicating average Heart rate and EER were significantly higher in case of group II who were engaged in striking operation in bending position i.e. 124.60 beats/min and 11.09 kJ/min, respectively as compared to other group workers.

In the nutshell, it can be concluded that group II workers (striking) were found to be most strenuous activity; however, group III workers (cooling) were least exhaustive one.

CONCLUSION

The present study shows that forging workers of unorganised sector are exposed to multi-occupational hazards which cumulatively increase the susceptibility of occupational stress and adverse health outcomes. More than 90% of the respondents identified awkward working posture and repetitive motion as the most common ergonomic hazards. These observations are in agreement with findings of Singh *et al.* (2013) who observed high prevalence of musculoskeletal disorders among workers engaged in repetitive manual tasks in small scale industries. Prolonged static postures and repetitive movements increase the biomechanical loading of the spine and upper extremities, predisposing workers to chronic musculoskeletal disorders.

Chemical and environmental hazards were common, particularly smoke, dust, extreme heat and noise. Continuous exposure to these hazards can affect respiratory health as well as thermal and psychological comfort. Similar findings were noted by Pandit and Patil (2019), identifying air pollutants, heat and noise as the major occupational hazards of forging industries. Also, the widespread exposure to excessive work noise in the present study also supports Lindström *et al.* (1984), showing that too much noise at work affects concentration and work performance, and increases the risk of accidents at work.

The study also found biological hazards, such as Itching, rashes and skin infections, to be highly prevalent among cooling workers. Constant contact with contaminated cooling water can explain the high incidence of skin conditions. These findings indicate the need to improve hygiene standards in the workplace and the management of cooling water in the forging industries.

The health surveillance outcomes revealed low utilization levels for occupational healthcare services. Self-medication was utilized by the majority, and only a minority of workers sought professional assistance. The same health-seeking behaviour was reported by workers in the informal sector in India by Saha *et al.* (2010), and was attributed to low income, lack of awareness, and inadequate healthcare services as barriers to proper healthcare.

The present study findings support the Job Demand–Control model (Karasek, 1979). This study found high levels of occupational stress and ill health for workers in jobs with high levels of physical demand and low levels of control; for forging workers, this is the case with repetitive, high demand work with low recovery in high stress environments with little to no control.

The study brought to light the concern and the complexity of health impacts from the forging trade, combined with exposure to chemicals and biological threats. This research called attention to the need for an urgent redesign of the workplace. The addition of engineering controls to reduce heat and noise, improvements to ventilation, protective equipment, periodic health surveillance, and risk mitigation all combined to improve the wellbeing of the workers.

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