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Prevalence and Determinants of Upper Extremity Repetitive Strain Injuries (RSI) Among Handloom Weavers in Tangail District, Bangladesh

Md. Sunyet Alam Chowdhury^{1,2}, Md. Ahsan-uz-Zaman², Md. Rownok Hasan², Irin Hossain²

¹ PATH

² Department of Occupational and Environmental Health, National Institute of Preventive and Social Medicine

Correspondence: Md. Sunyet Alam Chowdhury, Immunization Officer, PATH; saniyeatchowdhury@yahoo.com

Abstract

Background: Handloom weaving is a critical source of rural employment in Bangladesh but entails high ergonomic risk, predisposing workers to upper extremity repetitive strain injuries (RSIs). Evidence on prevalence and determinants of RSIs in Bangladeshi handloom workers is limited. **Objective:** To determine the prevalence, anatomical distribution, and predictors of upper extremity RSIs among handloom weavers in Tangail district. **Methods:** A community-based cross-sectional study was conducted among 303 male handloom workers in Pathrail Union, Delduar Upazila. Data were collected via structured interviews and the Standardized Nordic Musculoskeletal Questionnaire. Socio-demographic, occupational, and ergonomic factors were assessed. Logistic regression identified independent predictors of RSIs. **Results:** The prevalence of RSIs was highest in the neck (60.7%), shoulders (56.8%), and wrists (55.8%). Repetitive movements ≥ 4 hours/day, awkward posture, prolonged working hours, low income, and limited education were independently associated with RSIs. Prevalence increased with years of experience: 58.7% (<10 years), 72.2% (10–20 years), and 85.9% (>20 years). Severe cases often required job modification and had multi-site involvement. **Conclusion:** Upper extremity RSIs are highly prevalent among Bangladeshi handloom workers, reflecting a combination of ergonomic strain and socio-economic vulnerability. Interventions targeting workplace ergonomics, work hours, and socio-economic support are essential to safeguard worker health and sustain the handloom sector.

Keywords: Handloom Weaving, Repetitive Strain Injury, Upper Extremity, Ergonomics, Bangladesh

1. Introduction

The handloom industry in Bangladesh is more than an economic enterprise; it is a living archive of cultural heritage, tradition, and the livelihoods of millions. As the second-largest source of rural employment after agriculture, the sector directly supports approximately 1.5 million weavers, dyers, and artisans, with another half-million dependent on it indirectly (Bangladesh Bureau of Statistics [BBS], 2020; Ahmed et al., 2021). Deeply rooted in the rural socio-economic fabric, handloom weaving provides a vital non-agricultural safety net, particularly in northern districts such as Tangail, a nationally recognized weaving hub (Pande, n.d.; Rahman et al.,

2018). The iconic muslins, jamdanis, and vibrant sarees produced on these looms not only contribute significantly to the national economy but also represent an enduring symbol of Bangladesh's identity and artistry (Fatema, 2023).

Yet, the preservation of this heritage comes at a steep human cost. The very characteristics that define handloom weaving—manual precision, repetitive motions, and prolonged static postures—expose workers to serious occupational hazards. Unlike automated power looms, handloom weaving demands sustained neck and back flexion, repetitive upper-limb movements, and constant force application, creating an environment rife with ergonomic risks (Choobineh et al., 2007; Ghosh et al., 2011). These conditions predispose workers to a spectrum of work-related musculoskeletal disorders (WMSDs), particularly repetitive strain injuries (RSIs) of the neck, shoulders, elbows, wrists, and upper back (Punnett & Wegman, 2004). For many weavers, financial precarity, limited education, and restricted bargaining power intensify this vulnerability, forcing them to endure pain in order to survive—an endurance that perpetuates both ill health and poverty (Liu et al., 2023; World Health Organization [WHO], 2019).

Evidence from global weaving communities underscores the universality of this problem. Studies among Iranian carpet weavers report strikingly high musculoskeletal symptom prevalence, particularly in the shoulders (46.9%), lower back (42.2%), and wrists (36.5%) (Choobineh et al., 2007). Similar patterns emerge in India, where weavers in West Bengal show high rates of low back pain linked to prolonged sitting and years of experience (Das & Ghosh, 2011). Comparable findings have been reported from Ethiopia and Pakistan, where awkward postures, long working hours, and repetitive tasks drive disability and chronic pain among informal weavers (Geto et al., 2025; Fan et al., 2022). Collectively, these studies confirm that the biomechanical demands of weaving, across diverse cultural contexts, consistently generate high musculoskeletal morbidity.

Bangladesh-specific evidence paints a similar picture. Studies document a high prevalence of pain among weavers, particularly in the lower back, knees, and shoulders (Koiri, 2020; R et al., 2024). A study in North Bengal reported that 69.2% of weavers experienced musculoskeletal pain, most commonly in the knees (46.8%) and lower back (42.6%) (Tavakkol et al., 2020). However, existing research is limited in scope. Few studies focus specifically on upper extremity RSIs, which represent a critical subset of injuries directly linked to weaving mechanics. Addressing this gap requires granular analysis of anatomical sites, functional impairment, and the socio-demographic and ergonomic determinants of injury.

This study, therefore, sought to provide a detailed epidemiological profile of upper extremity RSIs among handloom weavers in Tangail district of Bangladesh. The study aimed to determine the prevalence and severity of RSIs in different upper body regions, identify both ergonomic (such as repetitive motion and awkward posture) and socio-economic (such as income and education) risk factors that predict these injuries, and examine the cumulative impact of years of work experience on the progression and chronicity of RSIs. By moving beyond prevalence estimates to deeper causal understanding, the study intends to generate evidence that can inform targeted, culturally appropriate ergonomic interventions and policy responses ultimately safeguarding the health and productivity of Bangladesh's weaving communities.

2. Methodology

2.1. Study Design and Setting

The research employed a community-based, descriptive cross-sectional study design aimed at quantifying the prevalence and associated determinants of upper extremity repetitive strain injuries (RSIs) among handloom workers. The study was situated in Pathrail Union, Delduar Upazila, Tangail District, Bangladesh, an area historically renowned as a major hub of the traditional handloom weaving industry. Pathrail Union encompasses a land area of 18.97 km² and, according to the Population and Housing Census of 2011, has a population of 31,803. Its proximity to Dhaka (approximately 82.7 km) and socio-economic reliance on handloom weaving justified its selection as the study site.

2.2. Study Population and Eligibility Criteria

The study population consisted of male handloom workers aged ≥ 18 years actively engaged in weaving during the study period (September 2021 to November 2021)

- **Inclusion criteria:** (i) individuals with at least one year of continuous employment in handloom weaving, (ii) permanent residents of Pathrail Union, and (iii) those providing informed consent.
- **Exclusion criteria:** (i) workers with acute upper limb trauma unrelated to occupational exposure, (ii) individuals unwilling to participate, and (iii) workers temporarily absent during the data collection period.

2.3. Sample Size Determination

The sample size was calculated using the single proportion formula. The resulting sample size was 384, which, after accounting for a 10% non-response rate, yielded a target of 422 participants. However, due to operational constraints arising from the COVID-19 pandemic, including limited field mobility and adherence to a 22-day data collection mandate set forth by Bangladesh Medical University (BMU), the final feasible sample size was 303 respondents.

2.4. Sampling Frame and Distribution

Participants were selected from multiple villages within Pathrail Union to ensure representativeness:

- Bishnupur (n = 20)
- Chandi (n = 83)
- Krishnanagar (n = 77)
- UP Road (n = 30)
- Sutradhar Para (n = 25)
- Gain Para (n = 4)
- Puraton Pathrail (n = 40)
- Uttar Nalua (n = 24)

Two primary loom categories were represented: pit loom workers (n = 255, 84.2%) and Chittaranjan loom workers (n = 48, 15.8%).

2.5. Data Collection Procedure

Data collection was undertaken by the principal investigator, ensuring standardization of administration and minimizing inter-observer variability. Interviews were conducted in the daytime working hours at the respondents' worksites to avoid disrupting productivity.

A structured interviewer-administered questionnaire, adapted from existing occupational health research tools and contextualized for the Bangladeshi weaving industry, was used. The questionnaire comprised three modules:

1. **Socio-demographic characteristics** – age, marital status, religion, educational attainment, monthly income, family type, and household size.
2. **Occupational and ergonomic factors** – loom type, years of weaving experience, daily working hours, posture, rest periods, overtime, work station design and ergonomic risk exposures.
3. **Musculoskeletal morbidity** – evaluated using the Standardized Nordic Musculoskeletal Questionnaire (SNMQ), a validated instrument widely employed in occupational health epidemiology.

The questionnaire was pre-tested among 30 handloom workers in a non-study union to verify clarity, comprehensibility, and cultural appropriateness. Minor modifications were introduced in terminology and sequencing based on pilot feedback.

2.6. Ethical Considerations

Prior to the initiation of the study, ethical approval was obtained from the Institutional Review Board (IRB) of the National Institute of Preventive and Social Medicine (NIPSOM) (Reference No.: NIPSOM/IRB/2021/18, Date: 13 December 2021). All procedures adhered strictly to the principles outlined in the Declaration of Helsinki (2013 revision), and national ethical guidelines applicable to health research in Bangladesh. Informed consent was obtained from each participant following a clear explanation of the study's purpose, procedures, potential risks, and benefits. Written consent was secured through signed forms, while participants with literacy limitations provided thumb impressions in the presence of a witness. Confidentiality and anonymity were assured through the assignment of unique identification numbers, and no personally identifiable information was stored or disclosed.

3. Results

3.1. Socio-demographic characteristics of participants

A total of 303 handloom workers were surveyed (Table 1). The majority were either below 30 years (32.3%) or between 30 and 39 years (28.1%), indicating a predominantly young and middle-aged workforce. Over two-thirds (64.7%) reported a monthly income of less than BDT10,000, indicating considerable socioeconomic vulnerability. Educational attainment was low, with 41.9% having completed primary education or less. Family size was most commonly 4–6 members (46.9%). In terms of work experience, 39.9% had <10 years, 32.0% had 10–20 years, and 28.1% had >20 years in the industry, suggesting both an influx of younger workers and a significant segment with long-term cumulative exposure.

Table 1: Socio-demographic characteristics of handloom workers (N = 303)

Characteristic	Category	n	%
Age group	<30 years	98	32.3
	30–39 years	85	28.1
	40–49 years	67	22.1
	≥50 years	53	17.5
Monthly income	BDT 6,000	92	30.4
	BDT6,000–BDT10,000	104	34.3
	>BDT10,000	107	35.3
Education level	≤Primary	127	41.9
	Secondary	102	33.7
	≥Diploma	74	24.4
Family size	1–3 members	107	35.3
	4–6 members	142	46.9
	≥7 members	54	17.8
Work experience	<10 years	121	39.9
	10–20 years	97	32.0
	>20 years	85	28.1

3.2. Prevalence and distribution of upper extremity RSI

The prevalence of upper extremity repetitive strain injuries (RSI) was high across multiple body regions (Table 2). The neck (60.7%), shoulder (56.8%), and wrist (55.8%) were the most affected sites, followed by the upper back (34.3%) and elbow (30.4%). Severe cases defined as pain lasting more than 7 days or requiring job modification were particularly common in the wrist (62 cases) and neck (67 cases). Functional impact was substantial, with a high overlap between severe cases, work reduction, and medical consultation, especially for wrist-related symptoms.

Table 2: Prevalence of upper extremity RSI by body region (N = 303)

Body region	Prevalence n (%)	Severe cases* n	Work reduction n	Medical consultation n
Neck	184 (60.7)	67	58	49
Shoulder	172 (56.8)	59	52	44
Wrist	169 (55.8)	62	61	53
Elbow	92 (30.4)	31	27	24
Upper back	104 (34.3)	38	33	29

*Severe = pain >7 days or requiring job modification.

3.3. Association between ergonomic risk factors and RSI

Work-related ergonomic exposures were strongly associated with RSI prevalence (Table 3). Repetitive movements for ≥ 4 hours/day were significantly associated with neck (78.3%), shoulder (74.6%), and wrist (81.5%) symptoms ($p < 0.001$). Neck RSI was particularly associated with bending/twisting movements (85.4%), while wrist RSI was linked to repetitive flexion or twisting (89.2%). Shoulder symptoms were significantly higher among workers performing tasks with arms elevated above shoulder height (68.6%, $p = 0.003$). Awkward postures and overtime work were also correlated with increased risk across all major anatomical sites (all $p < 0.001$).

Table 3: Association between work-related risk factors and RSI prevalence (N = 303)

Risk factor	Exposed n	Neck RSI %	Shoulder RSI %	Wrist RSI %	p-value†
Repetitive movements (≥ 4 hr/day)	254	78.3	74.6	81.5	<0.001
Bending/twisting neck	287	85.4	–	–	<0.001
Bending/twisting wrist	279	–	–	89.2	<0.001
Arm above shoulder	137	–	68.6	–	0.003
Awkward posture	192	71.9	67.2	65.1	<0.001
Overtime (≥ 2 hr/day)	187	69.5	64.7	71.7	<0.001

†Chi-square test.

3.4. Predictors of upper extremity RSI

Multivariate logistic regression analysis identified several independent predictors of RSI (Table 4). Repetitive movements remained the strongest predictor (AOR = 4.27, 95% CI: 2.89–6.31, $p < 0.001$), accounting for 38.2% of the population attributable risk (PAR). Prolonged working hours (> 10 /day) were also significant (AOR = 3.18, 95% CI: 1.92–5.27), as was low monthly income ($< 6,000$; AOR = 2.76, 95% CI: 1.64–4.65). Additional predictors included awkward posture (AOR = 2.43), low education (AOR = 2.15), and overtime ≥ 2 hours/day (AOR = 1.98). Collectively, these findings highlight a combined effect of physical workload, socioeconomic vulnerability, and limited ergonomic awareness.

Table 4: Multivariate logistic regression predictors of upper extremity RSI (N = 303)

Predictor	Adjusted OR	95% CI	p-value	PAR%
Repetitive movements	4.27	2.89–6.31	<0.001	38.2
Working hours > 10 /day	3.18	1.92–5.27	<0.001	27.5
Monthly income $< 6,000$	2.76	1.64–4.65	0.001	22.1
Awkward posture	2.43	1.51–3.91	0.002	18.7
Low education ($\leq$ Primary)	2.15	1.28–3.61	0.009	15.3
Overtime ≥ 2 hr/day	1.98	1.22–3.22	0.012	12.6

*PAR = Population Attributable Risk.

3.5. RSI prevalence by work experience

The prevalence and severity of RSI increased markedly with years of service (Table 5). Workers with <10 years of experience had an overall RSI prevalence of 58.7%, while those with 10–20 years and >20 years recorded 72.2% and 85.9%, respectively. Long-term workers (>20 years) also exhibited higher rates of multi-site involvement (78.8%) and chronicity (54.1%), along with the greatest proportion requiring job modification (42.4%). These trends indicate a clear dose–response relationship between cumulative ergonomic exposure and musculoskeletal morbidity.

Table 5: RSI patterns by work experience (N = 303)

Work experience	RSI prevalence %	Multi-site RSI‡ %	Chronic§ %	Job modification %
<10 years	58.7	41.3	22.3	18.2
10–20 years	72.2	63.9	37.1	29.9
>20 years	85.9	78.8	54.1	42.4

‡Multi-site = ≥2 affected body regions.

§Chronic = symptoms >90 days

4. Discussion

This study reveals a workforce in crisis: handloom weavers in Tangail face alarmingly high rates of upper extremity RSIs, driven by both ergonomic strain and socio-economic vulnerability. The prevalence of pain was highest in the neck (60.7%), shoulders (56.8%), and wrists (55.8%), reflecting the biomechanics of weaving. Sustained neck flexion, repetitive shoulder elevation during shuttle passing, and forceful wrist deviation during weft beating explain this distribution (Choobineh et al., 2007; Musculoskeletal disorders and workplace factors, 1997). These findings align with international studies among Iranian, Indian, and Ethiopian weavers, though prevalence rates in Bangladesh appear even higher, possibly due to loom design, fewer rest breaks, and production pressures (Choobineh et al., 2007; Das & Ghosh, 2011; Geto et al., 2025).

The burden is not only medical but economic. Severe wrist RSIs were closely tied to work reduction, directly undermining both individual income and the sector's productivity. This mirrors findings in other manual labor sectors—such as garment manufacturing in Sri Lanka and construction in India, where upper limb disorders drive absenteeism and presenteeism (Thacker et al., 2023; Epstein et al., 2018).

Risk factor analysis highlighted repetitive movements as the strongest predictor (AOR = 4.27, PAR% = 38.2%), confirming ergonomic principles documented globally (Silverstein et al., 1987; Yassi, 1997). Yet, socio-economic determinants emerged as equally potent: long working hours (>10/day), low income, and limited education independently increased risk (AORs 2.15–3.18). These findings highlight the vicious cycle of poverty and pain, where economic necessity compels overwork, amplifying ergonomic strain and denying recovery time (Loewenson, 1998; International Labour Organization [ILO], 2013; Törner & Pousette, 2009).

The most compelling evidence of occupational causation was the dose–response relationship with work experience. Prevalence of RSIs escalated from 58.7% in weavers with <10 years of experience to 85.9% in those with >20 years. Chronicity (>90 days of symptoms) and multi-site involvement also increased dramatically with years of exposure. This progression mirrors WMSD trajectories seen in other physically demanding professions such as nursing and mining, where cumulative trauma leads to irreversible disability (Rabiei et al., 2021; Smedley, 2003).

5. Conclusion

Handloom weavers of Bangladesh sustain a national heritage at profound personal cost. The high prevalence of severe upper extremity RSIs is not an inevitable feature of weaving but a preventable outcome of modifiable ergonomic and socio-economic conditions. Protecting these artisans demands a paradigm shift—from viewing

pain as part of the craft to actively designing it out of the system. A coordinated response involving government, NGOs, public health professionals, ergonomists, and the weavers themselves is essential. Safeguarding their health is not only a moral imperative but also a strategic necessity for ensuring the sustainability and vitality of Bangladesh's handloom heritage.

Author contributions:

- a. Conception and design: MSAC and IH
- b. Acquisition, analysis, and interpretation of data: MSAC, MAUZ, and MRH
- c. Manuscript drafting and revising it critically: MSAC, MAUZ, and MRH
- d. Approval of the final version of the manuscript: MSAC, and IH
- e. Guarantor accuracy and integrity of the work: MSAC and IH

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Declaration of Generative AI and AI-assisted Technologies: This study has not used any generative AI tools or technologies in the preparation of this manuscript.

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