Evaluation of Related Risk Factors in Number of Musculoskeletal Disorders Among Carpet Weavers in Iran

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ABSTRACT

Background: Musculoskeletal disorders (MSDs) are a common problem among carpet weavers. This study was undertaken to introduce affecting personal and occupational factors in developing the number of MSDs among carpet weavers.

Methods: A cross-sectional study was performed among 862 weavers in seven towns with regard to workhouse location in urban or rural regions. Data were collected by using questionnaires that contain personal, workplace, and information tools and the modified Nordic MSDs questionnaire. Statistical analysis was performed by applying Poisson and negative binomial mixed models using a full Bayesian hierarchical approach. The deviance information criterion was used for comparison between models and model selection.

Results: The majority of weavers (72%) were female and carpet weaving was the main job of 85.2% of workers. The negative binomial mixed model with lowest deviance information criterion was selected as the best model. The criteria showed the convergence of chains. Based on 95% Bayesian credible interval, the main job and weaving type variables statistically affected the number of MSDs, but variables age, sex, weaving comb, work experience, and carpet weaving looms were not significant.

Conclusion: According to the results of this study, it can be concluded that occupational factors are associated with the number of MSDs developing among carpet weavers. Thus, using standard tools and decreasing hours of work per day can reduce frequency of MSDs among carpet weavers.

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1. Introduction

Carpet hand weaving is common in many countries such as Iran, Pakistan, Afghanistan, India, Turkey, China, Egypt, Russia, and Nepal. Production of hand-woven carpets is one of the most important parts of small-scale industry [1]. About 12.2% of Iranian households gain more than 40% of their total earnings by carpet weaving [2]. Carpet weaving is a monotonous profession that requires long hours of static work. Because of the awkward posture, repetitive movements, contact stress, and long working time, it is a high-risk occupation for developing musculoskeletal disorders (MSDs) [3,4].

MSDs are a common health problem and a main cause of disability in the world. The economic loss from MSDs affects individuals and societies [5]. MSDs related to work are an essential problem in developing countries [4]. Prevalence of MSDs in Iranian carpet weavers is higher than in the general population in Iran and outbreaks of symptoms in upper limbs are higher than other limbs [6]. Many such as psychosocial, personal, occupational, and social factors are important in MSD prevalence [7,8].

In recent years, researchers have investigated related risk factors with developing MSDs. The effect of work station design in prevention of MSDs was examined in the carpet hand-weaving industry [5] and also the prevalence of upper limb problems associated with hand tools design among carpet weavers was studied [9]. Also, the association between sex difference and work stressor with the MSDs prevalence were explored in weavers [4]. Factors associated with upper limbs MSDs among female carpet

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workers were investigated [10]. Recently, the continuous assess-
ment of the upper arm and back postures and estimation of
biomechanical load subtasks using inclinometers were studied [11]
and the prevalence of musculoskeletal pain and its association with
psychosocial factors were determined among rural hand-woven
carpet weavers in Iran [8]. The impact of the traditional and ergo-
nomically designed workstations on trunk posture and cumulative
compression load were evaluated in carpet weavers [12]; the
researcher tried to estimate prevalence of MSDs or any relation
between the MSDs and many factors.

The relationships of certain occupational and individual factors
with the number of occupational injuries were evaluated by using
random effects zero-inflated Poisson regression [13]. Poisson
regression models with random intercept were fitted to explore
prevalence of musculoskeletal pain by considering personal,
occupational, and social characteristics in 28 countries [7];

Thus identification of related factors to reduce these disorders
among carpet weavers is important. In the previous study [3], we
found no research that identifies types of factors cause to decrease or
increase the number of body parts MSDs among carpet weavers
using count models. The objective of the current research is to
investigate personal and occupational factors in developing the
MSDs to introduce affecting factors in the frequency of MSDs
among Iranian carpet weavers.

2. Materials and methods

2.1. Data

Data of this cross-sectional study were randomly selected from a
list that included the name and address of weavers. Sample size was 862, and samples were selected using stratified random sam-
ppling from seven towns (Tabriz, Marand, Herris, Kashan, Nain,
Golpayegan, and Kerman) with regard to workhouse location in
urban or rural regions [3]. A questionnaire that consists of personal,
workplace, and tools information and a modified Nordic MSDs
questionnaire with seven questions about pain existence in upper
limbs, including shoulder, wrist, forearm, arm, hand, finger, and
elbow was used to collect data.

Choobineh et al investigated the reliability and validity of the
Nordic questionnaire [14]. Mokhtarinia et al evaluated the reli-
ability and validity of Persian version of this questionnaire [15].
They reported that all of the items of the questionnaire had acceptable
face validity. The intraclass correlation coefficient (> 0.7) and the
standard error of measurement (0.56–1.76) were reported as
acceptable and the Kappa coefficient was calculated as 0.78–1.00
[15].

2.2. Variables

For all studied individuals in this research, factors such as age
(years), sex (0, female; 1, male), main job (0, no; 1, yes), work
experience (years), carpet–weaving loom (0, moving vertical; 1,
fixed vertical), weaving style (0, Turkish; 1, Persian), weaving comb
(0, metallic; 1, wooden), were independent variables. The fre-
quency of body parts involving the MSDs is a dependent variable
ranging from 0 to 7.

2.3. Statistical analysis

In the data set related to the MSDs among carpet weavers in the
towns, $Y_{ij}$ is the number of MSDs in the $i$th person and $j$th town. The
frequency of MSDs has count property among carpet weavers. We
consider $Y_{ij}$ as an independent random variable for an available
event in any time and the occurrence of each event in each period,
then, $Y_{ij}$ has a Poisson distribution [16].

For appropriateness of this distribution is that the mean and
variance are equal. If this assumption is not valid, the other distri-
bution such as negative binomial (NB) may be appropriate [17].

Thus, we consider the variance of the NB distribution as $\mu_j
and \sigma_j = \mu_j + \alpha \mu_j$. Then $\alpha = 1/r$ is over-dispersion parameter.

To measure association between the number of MSDs and
mentioned risk factors in towns, a mixed Poisson regression was
used. The mixed Poisson regression models are used for analysis of
count data. In this model, it is assumed that random effect has log-
normal or gamma distribution [18].

Because of significant over-dispersion parameters in Poisson
gamma and Poisson log-normal models, an NB model with normal
random effect was used.

In this study, the full Bayes approach is used for all the model
parameters estimation. Classical methods for analysis of non-
discrete data are based on the asymptotic normality assumption
that this assumption does not always holds [19]. Compared to the
maximum-likelihood estimation, Bayesian methods are able to
model the uncertainty of estimation and to incorporate the prior
information [20]. Random effect create a hierarchical structure [21]
and gets enough attractive for using Bayesian hierarchical approach
[21].

The Gibbs sampler based on Markov chain Monte Carlo and
noninformative priors were used. In the all-fitted models, the co-
efficients are modeled using noninformative multivariate normal,
$N_0 - \beta \sim N_0 (0,10\sigma)$. It was considered two parallel chains for the
variance component of random effect and gamma distribution
$\Gamma(0.01,0.01)$ in Poisson log-normal and NB models. Also, it was
considered a gamma distribution $\Gamma(0.01,0.01)$ for NB over-
dispersion parameter. The prior of over-dispersion parameter was
considered as gamma distribution $\Gamma(0.1,0.1)$ in Poisson gamma
model. For independence between product samples, number of
initial values are considered, such as 5,000, 5,000, and 10,000 and
the number of lags of sampling as 30, 40, and 50 in Poisson log-
normal, Poisson gamma, and NB models, respectively. Numbers of
product samples were 5,000 in three models. Convergence of
chains was examined with trace plots, Gelman–Rubin, Geweke,
and Raftery–Lewis convergence diagnostics [21]. Bayesian Infer-
ence done based on statistical computations such as mean, stand-
ard deviation, 95% credible interval. The deviance information
criterion (DIC) was used for comparison between models and
model selection. Pearson Chi-square statistics were used for ex-
amination goodness of fit. The parameters of models were esti-

mated using Open BUGS [22] and R [23] software. OpenBUGS
Bayesian inference Using Gibbs Sampling is a computer software
that analyses complex statistical models based on Markov chain
Monte Carlo methods and it is the open source variant of WinBUGS
that can run under Windows as well as from inside the R statistical
package.

3. Results

For this study, mean (SD) of age, history, and the number of
MSDs was 36.01 (14.80) years, 21.81 (15.37) years, and 2.54 (2.39),
respectively (Table 1). The majority of participants (72%) were fe-
male. Carpet weaving was the main job of 85.2% of participants in
this study. A metallic comb was used by 50.5% of carpet weavers
and 49.5% used a wooden comb. The majority (67.5%) of carpet
weavers used Persian weaving and others used Turkish weaving.
Fixed vertical and moving vertical looms were used by 32.4% and 67.6%, respectively (Table 2).

No MSDs symptoms were reported by 22.4% of the study sample; 20.5% reported symptoms in one region, 16.5% in two regions, 10.8% in three regions, 6.1% in four regions, 7.5% in six regions, and 9.5% in all seven regions.

Poisson models with gamma and log-normal random effect fitted for specific effects in towns. Best model selected by DIC. Values of DIC were 3,766.0, 3,768.0, and 3,531.0 for Poisson log-normal, Poisson gamma, and NB models, respectively. The NB mixed model has lowest DIC. The Geweke statistics were between normal, Poisson gamma, and NB models, respectively. The NB model, which is statistically significant (95% credible interval = 0.217, 0.426; Table 3), found that weaving comb is a risk factor for developing MSDs [5], but our study did not conclude that. Afshari et al showed that weaving comb for short periods results small increases the compression load on the lower back [12]. Afshari et al also mentioned using weaving comb as a risk factor for development of disorders in the shoulder region among carpet weavers [11].

In this study, people whose their main job is carpet weaving were in the majority (85.2%). These people want to find more income and be assigned more hours to this work. Allocating long hours to work and repeated movement to weave 30 nodes are risk factors for developing MSDs. This amount of work was 8 hours in 60% of weaving workers [24,25]. Afshari et al mentioned that the median of trunk flexion angle in weavers during knotting and compacting subtasks was 18° and 13°, respectively and for 4.5% of the working time, the weavers worked with arms elevated by > 45° [11].

Specific effect of every town is considered in the fitted models. Random effect is significant. This can be because of various conditions in every town that affect the MSDs [17].

One of the limitations in this study is that data collected with weaver self-reporting about MSDs. Furthermore, some variables aren’t significant in comparison with other studies and it may be because of using different models in this study.

According to the results of this study, it can be concluded that occupational factors such as weaving style and main job are associated with developing the number of MSD among carpet weavers. The majorities of these problems are due to poor ergonomics and work posture and long hours of static working condition in the carpet industry. Thus, using standard tools and methods, and reducing hours of work per day can decrease the number of the MSDs among carpet weavers.

4. Discussion

According to the analysis, a random effect NB has the best goodness of fit on this data set, as deviance statistics of this model was the lowest (3521.0). There were more female than male carpet weavers. One of the important results in this study is the significance of weaving style on MSD occurrence, as workers who used Turkish weaving were exposed to MSD less than those who used Persian weaving. This result is similar to Motamedzade and Moghimbeigi [3], but it is in contrast with Choobineh et al’s study [24]. Motamedzade and Moghimbeigi suggested that the reason for this paradox is the use of combs with lower weight in Turkish-style weavers [3]. The main job is also one of the most significant and important factor in the number of MSDs. This finding also is similar to Motamedzade and Moghimbeigi’s study [3]. People whose main job was carpet weaver had greater risk of MSDs.

Choobineh et al showed that weaving comb is a risk factor for developing MSDs [5], but our study did not conclude that. Afshari et al showed that weaving comb for short periods results small increases the compression load on the lower back [12]. Afshari et al also mentioned using weaving comb as a risk factor for development of disorders in the shoulder region among carpet weavers [11].

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Conflicts of interest

Conflicts of interest all contributing authors declare no conflicts of interest.

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**Table 1** Summary statistics of quantitative variables in models

| Variable             | Mean  | SD    | Max  | Min  |
|----------------------|-------|-------|------|------|
| Number of MSDs       | 2.54  | 2.40  | 7    | 0    |
| Age (y)              | 36.0  | 14.8  | 82   | 13   |
| Work experience (y)  | 21.2  | 15.38 | 50   | 1    |

MSDs, musculoskeletal disorders; SD, standard deviation.

**Table 2** Summary statistics of qualitative variables in models

| Variable               | Frequency | %    |
|------------------------|-----------|------|
| Sex                    |           |      |
| Female                 | 638       | 77.2 |
| Male                   | 224       | 27.1 |
| Main job               |           |      |
| Yes                    | 734       | 85.2 |
| No                     | 128       | 14.8 |
| Weaving comb           |           |      |
| Metallic               | 435       | 50.5 |
| Wooden                 | 427       | 49.5 |
| Weaving style          |           |      |
| Persian                | 582       | 67.5 |
| Turkish                | 280       | 32.5 |
| Carpet-weaving loom    |           |      |
| Fixed vertical         | 279       | 32.4 |
| Moving vertical        | 583       | 67.6 |

**Table 3** The negative binomial random effect model

| Parameters               | Mean    | SD      | MC_error |
|--------------------------|---------|---------|-----------|
| Intercept                | 0.2189  | 0.003148| -0.1221   |
| Age (y)                  | 0.04505 | 3.118   | -0.4924   |
| Sex (female – 1)         | 0.1137  | 0.08972 | -0.01127  |
| Work experience (y)      | 0.007971| 3.143   | -0.06188  |
| Main job (yes – 1)       | 0.304   | 0.09911 | 0.00126   |
| Carpet-weaving loom      | -0.3102 | 0.1916  | -0.03675  |
| (Fixed vertical – 1)     |         |         |           |
| Weaving style (Persian – 1) | 0.8668 | 0.2584  | 0.005168  |
| Weaving comb (wooden – 1) | -0.2595| 0.1453  | -0.00233  |
| Sigma                   | 0.2036  | 0.1045  | 0.001958  |
| r                       | 0.4611  | 0.04883 | 0.3709    |

SD, standard deviation.
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