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PRELIMINARY RISK ASSESSMENT OF WORK-RELATED MUSCULOSKELETAL DISORDERS IN SMALL-SCALE FEED MILLS

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Abstract. Feed mills of low capacities have become the major source of feeds for the agrarians in developing countries. Operations carried out in these feed mills do not totally conform to the standard operations and safety requirements in large scale feed mills. Therefore this paper is aimed at assessing the possibility of work-related musculoskeletal disorders (WMSDs) in these feed mills. A preliminary assessment of the risk was carried out using onsite investigation, interview of workers and a pen-and-paper based analytical tools. Feed discharge, weighing and manual material handling (lifting) operations were evaluated with Quick Exposure Check (QEC) and Rapid Entire Body Assessment (REBA) tools. Results showed that 70 and 60% of the workers experience body pains after and during work respectively. The workers expressed dissatisfaction due to the pains experienced in different body regions. QEC and REBA evaluation showed that the body regions with a high risk of WMSDs are back, shoulder and neck regions for discharge operation; wrist, back, shoulder and neck regions for weighing operation; and back, shoulder, neck, wrist, legs, and elbow regions for manual material handling. WMSDs mitigation measures were suggested for each operation based on identified cause.

Keywords: *feed weighing, feed mixing and discharge, manual handling, QEC, REBA.*

Introduction

Health problem has become synonymous with many small-scale productions. These health problems include musculoskeletal disorders, respiratory disorders, repetitive stress injuries, cardiovascular disorders, and the likes. Some basic features of the work environment have been associated with some of these health problems, especially when the physical requirement of an activity is higher than the physiological abilities [1]. Nearly all tasks on farms (e.g. machinery operation, driving mobile machinery and vehicles, using

workshop tools, using a hammer mill, manual handling lifting/lowering, pulling/pushing, carrying, etc.) involve ergonomic problems which should always be assessed [2].

One of the ways to reduce the prevalence of health issues is to adequately investigate and assess the presence of health risk. Musculoskeletal disorder is a major risk factor not only in small-scale mills but in agriculture [3 - 10]. In order to assess this risk for a particular work setting, some analytical tools are made use of. They ultimately provide an estimated level of risk based on the observed disparity in certain factors pertaining to the work environment and user/worker. Some of the analytical ergonomic tools are: rapid upper limb assessment, RULA [11], Ovako working posture analysis system, OWAS [12], Dutch musculoskeletal questionnaire, DMQ [13], observation analysis of the hand and wrist [14], quick exposure check (QEC) [15], rapid entire body assessment, REBA [16], agricultural lower limb assessment, ALLA [17] etc. These ergonomic analytical tools have some limitations and advantages [18]; hence, they have been applied individually or jointly to assess the risk of WMSDs. They have also been applied by many industries before and after carrying out a particular intervention such as a lean workflow, workstation redesign, etc. [19].

Some of the industries where these analytical tools have been reportedly applied include; dairy farming [20], sawmills [21, 22], small-scale mining [23], cotton spinning [24], small-scale casting [25], small-scale gold mining and extraction [26], hand-woven carpet industry [27], small-scale forging [28], etc.

Feed milling and other types of milling has been identified as a process which needs attention due to certain risks [29], especially at the small-scale [30]. Omokhodion and Kolude [31] observed that 73% of the operators of small-scale mills have health problems like headache, backache, cough, rhinitis, wheezing, tinnitus and high blood pressure. These health conditions may be attributed to a lack of personal protective equipment despite the high dust level and high noise level of 88-90 dB [30]. Small and medium scale feed mills have been reported to generate noise levels around 114 dB [31]. Workers in these mills are exposed daily to the high noise level all through the 9 hour work period without any noise control equipment [30, 31]. Although, body injuries have been reported as another major health problem [32], there has been insufficient report on the WMSD risk level the workers in this industry are exposed to.

Ergonomic control measures inclusion in small-scale industrial operations is very low and has led to the high ergonomic hazard among workers [33].

More attention should, therefore, be paid to the extent to which workers in small-scale industries are exposed to WMSD [34]. This can be done by evaluating every activity and task carried out by the worker during a job section. In addition, the work environment of these workers can also be assessed for any unfit arrangement or settings capable of making the worker take a discomforting or awkward posture.

The work setting may have to be adjusted in line with the worker's anthropometry, physiology, and capability in order to reduce the risk of WMSD.

This type of WMSD assessment and workplace developmental processes has been applied to improve different work settings and several industrial activities and tasks. Therefore a WMSD risk assessment can be applied to identify the major problems, unfits and source of discomforts in the activities of small-scale feed milling.

This study, therefore, assesses the risk of WMSDs in small-scale feed mills using REBA and QEC analytical tools.

Materials and Methods

The feed milling operation was broken down into its unit operations and was collectively investigated in order to identify the specific problem in the process as well as proffering solution to them.

Characteristics of Sample Population

Thirty feed mill workers were randomly selected across ten small-scale feed mills in Ibadan, Nigeria. The areas the study covered include Apete, Moniya, Sango, Apata, Challenge, and Iwo road. The populace is actively involved in industrial production at various scales. Details of the sample population, machine, energy use, and other characteristics have been reported in Adetifa and Okewole [35].

Worker's Complaints

This assessment includes an onsite investigation and interview with workers. Information about the workers such as sex, age, work experience, and disability was collected. The workers interviewed highlighted some of the discomforts and pains experienced during and after work. They also highlighted the specific area of their body where this discomfort was experienced. Information about the characteristics of the workplace, work duration, and work requirement was also gathered.

WMSDs Risk Assessment

The feed mill workers were evaluated using QEC form to determine the risk of WMSDs in each of the three operations (i.e. discharging, weighing and materials handling operations). Two different categories of assessments were carried out and scored with the help of QEC i.e.

- I. Body regions (back, neck, shoulder/arm, wrist/hand)
- II. Other factors (work pace, vibration, driving, stress)

The scores were used in determining the extent of exposure of the body regions and the contribution of the other factors to the risk of work-related musculoskeletal disorder (WMSD) as reported by, McFarren [36].

The feed mill workers were also assessed using Rapid Entire Body Assessment (REBA) form to define the presence and level of risk of WMSDs. Three different assessments were carried out and scored with the help of REBA i.e.

- I. Trunk, neck, and legs
- II. Upper and lower arms, and wrists both hands
- III. Load/force and coupling factors and the activity

The interpretation of these scores determines the severity of the risk of musculoskeletal disorder (MSD) as reported in Middlesworth [16]. REBA has been checked for reliability and validity for diverse work situations.

Comparative Analysis

A correlation and t-test were carried out between the result of the REBA and QEC for each of the unit operations at 5% level of significance.

These analyses were done between the risk level assessments of the body regions which were both assessed by the two tools.

Also, this analysis was used to determine the significance of the effect of unit operations on the QEC and REBA scores.

Results and Discussion

Feed Mill Workers

It was discovered that a typical small-scale feed mill in the study location has an average of 6 workers which includes both the line and support staff. Although 32% of these workers are female, those working directly with the feed mill machines are majorly men of 25 - 40 years. With less than a year of work experience in feed milling, most of these workers spend close to 9 hours without a break.

From the survey carried out, it was discovered that 70% of the workers complained of always having body pains after work and 60% complained of pains during working (Figure 1). The workers also complained of not being comfortable at work which affects their work pace. In most cases, they will have to take some form of medications. Figure 2 depicts the specific body part where discomforts were felt. There were more complaints of discomfort in the back region followed by leg/thigh and shoulder regions. This explains why the workers complain of discomfort in some specific area of their bodies.

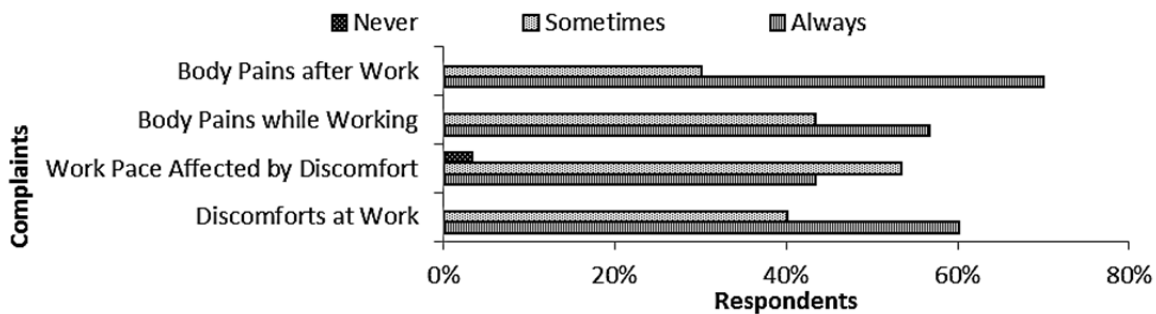


Figure 1. Complaints of workers in small-scale feed mills.

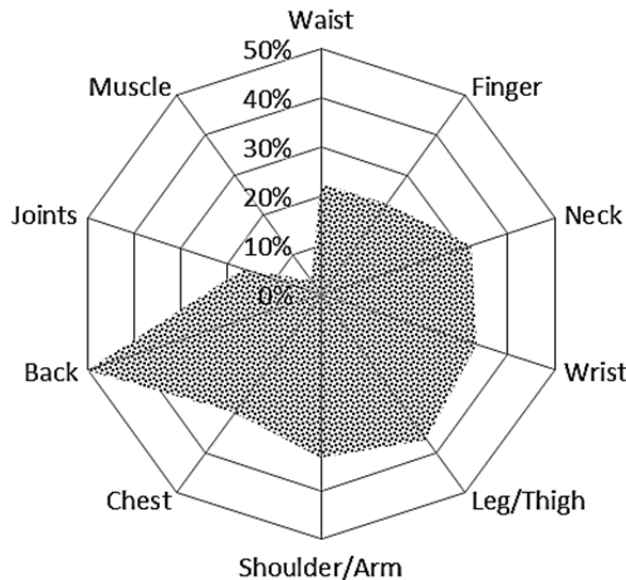


Figure 2. Complaints of body discomfort by workers in the small-scale feed mill.

Risk of WMSDs in Small-Scale Feed Milling Operations

Table 1 summarizes the QEC scores of the three investigated operations in small-scale feed mills. Based on the risk classification by McFarren [36], this result shows that the back and the shoulder regions of workers carrying out the discharge, weighing and manual material handling operations are exposed to a very high risk of WMSDs. This confirms the worker’s complaints in figure 2.

Table 1

Summary of QEC scores of operations in small-scale feed mills

	Discharging	Weighing	Manual Material Handling/Lifting
Back	41	39	48
Shoulder	43	44	49
Wrist	36	36	37
Neck	15	15	15
Driving	1	1	1
Vibration	1	1	1
Work pace	4	4	4
Stress	16	9	16

Figure 3 shows that over 90% of the workers carrying out the material handling operation are severely exposed to WMSD at the back and shoulder regions. The wrist and neck of these workers are at a high risk of WMSD. Table 2 summarizes the REBA scores of the three investigated operations in small-scale feed mills. This result shows that the back and the shoulder regions of workers carrying out the discharge, weighing and manual material handling operations are at a very high risk of WMSDs.

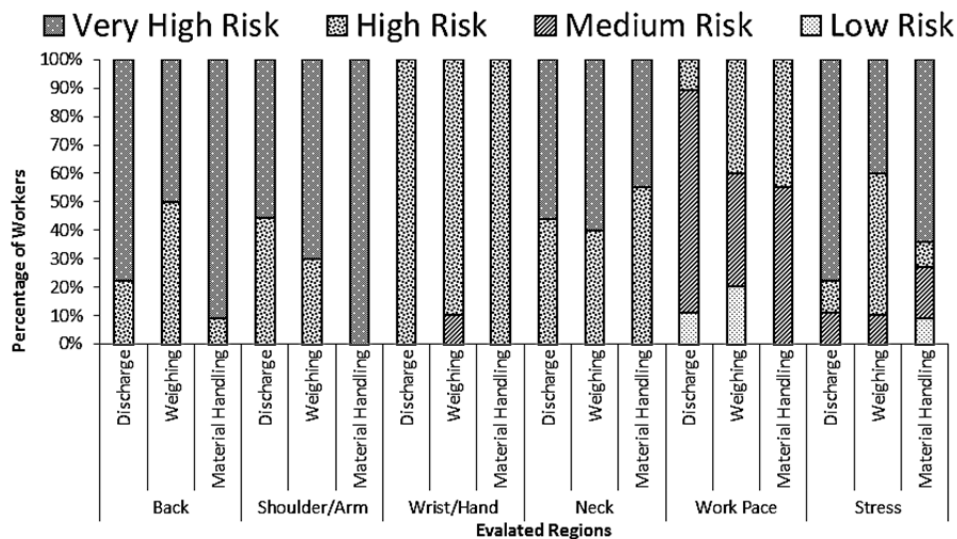


Figure 3. Distribution of the severity of the exposure to WMSDs across different operations in small-scale feed mills (from QEC scores).

Table 2

Summary of REBA scores of operations in small-scale feed mills

	Discharging	Weighing	Manual Material Handling/Lifting
Back	4	3	4
Neck	2	3	2
Leg	2	2	2
Load force	2	2	3
Shoulder (Left)	3	3	4
Shoulder (Right)	3	3	4
Wrist (Left)	1	2	2
Wrist (Right)	1	2	2

Continuation Table 2

Elbow (Left)	2	1	2
Elbow (Right)	2	1	2
Coupling	2	2	2
Activity	2	2	3

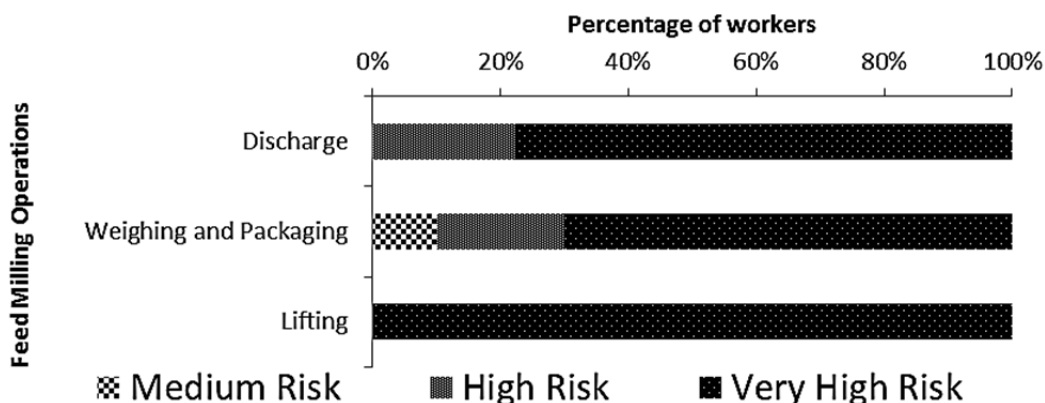


Figure 4. The severity of the risk of WMSDs in the operations of small-scale feed mills (from REBA scores).

WMSDs in the discharge operation of small scale feed milling

Around 80% of the workers carrying out this operation are at a very high risk of WMSD (figure 4). This extreme risk level is made clearer by the QEC results in figure 3 which reveals that the back, the shoulder, and the neck are the major body parts that are subjected to this high risk. From figure 5, it is clear that the major cause of this severe risk level is the location of the discharge chute on this mixer. The workers usually have to bend their back and neck, while they also lift the bag of feeds during the discharge from the mixer. According to Hochschuler [37], this type of task has a high risk of back injury. The risk becomes severe when this risk factor is coupled with other risk factors like sedentary lifestyle, overweight, smoking, etc. [37]. Sim [38] recommended that modifying the workstation may reduce cases of neck and upper limb pain. Therefore if the horizontal mixer is redesigned in such a way that the discharge chute is located at a height which fits the anthropometry of the workers, this risk can be mitigated.



Figure 5. Discharge operation; filling bags with feed (left), opening discharge gate (right).

WMSDs in the weighing operation of small scale feed milling

From figure 4, 70% of workers who carry out the operation are exposed to a very high WMSD risk while 20% are at high risk. QEC results in figure 3 shows that the wrist, back, shoulder and the neck are the major body parts that are subjected to this risk level. Figure 6 shows how the operation is carried out in a typical small-scale feed mill. Some workers usually have to bend their back and neck while they take measurement because they make use of the small weighing scales without a high platform. Using the flowering method (figure 6), the bags are closed up and then tied up with treads (instead of sealing), after which the bags are lifted off the scale. Although the flowering method of covering up bags has reduced muscle activity and exertion [39], when coupled with tying up the bags, the hand and wrist are subjected to WMSD [40] as a result of the bending of the wrist, task repetitiveness and carrying more than 4.5 kg. This operation also put the shoulder and back at risk. Some of the problems with this operation will be resolved when elevated weighing platforms and hand stitching machine are provided.



Figure 6. Weighing operation; flowering method of bag close up (left), weighing feeds (right).

WMSDs in the manual material handling operation of small scale feed milling

This operation is the most problematic and severe operation in a small scale feed mill, capable of imposing extreme biomechanical pressures on the back [41]. Figure 4 reveals that all the workers performing this operation were at a very high risk of the WMSD. It was specifically observed that there was a very high WMSD risk at the back and shoulder regions, higher than those recorded for other operations (figure 3). The neck, wrist, legs and the elbow are the other body parts that were subjected to this high risk (table 2).

From figure 7, it is clear that one of the risk factors is the method of lifting the load. The workers lift the loads with their backs deviating from the neutral position, thereby subjecting a load of 30 – 50 kg on the spine. The workers usually do not have any specific posture for lifting, but supports the load with any part of the body found convenient. This posture of manual handling can lead to back injury [37, 41].

Another risk factor is the amount of load carried which is more than the recommendation of NIOSH. According to NIOSH [42], a characteristic industrial worker can lift up to 23.13 kg. This is lower than 30 – 50 kg bags carried by the feed mill workers during an 8 hour shift. A typical worker in the feed mills under study carries up to 100 of

such bags for a minimum distance of 2 m within the working hours with little or no personal protective equipment and sufficient break.

In a typical small scale feed mill in the study area, it may be difficult to totally eradicate manual material handling due to the cost of material handling equipment. Therefore, one of the possible methods of mitigating WMSDs in this operation is to rearrange and redesign the layout [38] of these feed mills so as to reduce the points where the manual conveyance of products are required and also the distance to be covered during handling. Also, the size of the bags can be reduced to around 20 kg for easy handling. Another solution suggested by Digiesi [43] is job rotation, so as to reduce the risk of WMSDs as a result repetitive manual activities of arm and hand.



Figure 7. Manual material handling operation; loading hand truck (left), conveying materials during milling (right).

Comparative Analysis of QEC and REBA Scores

Table 3 shows the Pearson correlation coefficient and paired samples t-test between REBA and QEC evaluation of different body regions of workers in small-scale feed mills. A significant positive correlation was found to exist between the result of the QEC and REBA in the evaluation of back when performing the discharge and the weighing operations. This is in line with the report of Motamedzade [44]. Other significant positive correlations observed were the evaluation of the wrist and neck region during discharging and manual material handling operations. A significant negative correlation was observed between the QEC and REBA evaluations of the shoulder during weighing and manual material handling operations. Table 4 shows that based on QEC evaluation, the type of operation carried out is a major causative factor to the risk of WMSDs at the back, shoulder and neck regions, while for REBA evaluation, the type of operation affected the score for legs and wrists.

Table 3

Pearson correlation between REBA and QEC evaluation of operations in small-scale feed mills (n=30)

	Discharging		Weighing		Manual Material Handling	
	R	t Stat	R	t Stat	R	t Stat
Back	0.36	-0.80	0.43	-1.50	-0.07	-2.08
Shoulder	0.10	-5.50	-0.31	-4.27	-0.61	-3.50
Wrist	0.35	-2.69	0.18	3.21	-0.18	1.34
Neck	-0.06	-2.67	0.00	-0.19	0.63	-0.23

Table 4

ANOVA of QEC and REBA evaluation between operations in small-scale feed mills

Evaluation Tool	Evaluated Regions/Factors	P-value
QEC	Back	*
	Shoulder	0.006
	Wrist	0.521
	Neck	*
	Work Pace	0.808
	Stress	0.267
REBA	Back	0.201
	Neck	0.086
	Leg	0.011
	Left Shoulder	0.241
	Right Shoulder	0.241
	Left Wrist	0.031
	Right Wrist	0.031
	Left Elbow	0.207
Right Elbow	0.207	

*p-value less than 0.001

Conclusion

A preliminary assessment of the risk of WMSD in small-scale feed mills has been carried out. This assessment comprises an assessment using onsite investigation and interview of workers and a qualitative assessment of three unit-operations (feed discharge, weighing and manual material handling) using QEC and REBA which are ergonomic evaluation tools. This study revealed that the back and the shoulder regions of workers carrying out the discharge, weighing and manual material handling operations are exposed to a very high risk of WMSDs. Around 80% of the workers in the feed discharge section were at a very high risk of WMSD because the discharge chute on the mixer was very low. In the weighing operation, due to the low platform used in weighing and the absence of stitching machine, 70% of workers are exposed to a very high WMSD risk while 20% are at high risk. The manual material handling operation was identified as the most severe because all the workers carrying out this operation were at a very high risk of WMSD as a result of poor lifting method. This study has shown the severe health risk workers in the small-scale feed mills are exposed to as a result of the method and machines used. It is therefore imperative to pay more attention to this sector.

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