Egyptian Journal of Occupational Medicine, 2017; 41 (1) : 1-17

OCCUPATIONAL INJURIES AMONG WORKERS IN A NITROGENOUS FERTILIZERS COMPANY, EGYPT

By

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Abstract

Introduction: During manufacturing of fertilizers, workers may be exposed to several occupational accidents. Fertilizers industry is one of the most important industries in Egypt. It is considered a subsector of the chemical industries which is based on the usage of numerous types of chemicals in large quantities. **Aim of work:** to estimate the frequency and severity rates of occupational injuries among workers in a nitrogenous fertilizers company and to describe their pattern and possible risk factors. **Materials and methods:** The study comprised two parts; part I which was a record-based study of occupational injuries during a period of three years and part II which was a case-control study of the occupational injuries during the same period. **Results:** Having job strain, absence of past jobs, non using of gloves, and sometimes using of gloves and helmet were independently associated with the likelihood of having occupational injuries (OR= 1.9, 1.9, 7.7, 5.3, and 2.4, respectively). **Conclusion:** Workers at Fertilizers Company face many occupational injuries that could be ameliorated through environmental, administrative and personal measures by the implementation of an effective occupational health and awareness programs.

Key words: Occupational injuries, Chemicals industry, Nitrogenous fertilizers, Fertilizers Company and Job strain,

Introduction

Fertilizers are substances providing nutrients to plants to increase or sustain optimal crop yield (Chien et al., 2009). They are broadly divided into organic and inorganic. Organic fertilizers that may be suitable for commercial use are by-products of livestock, fish, and food and other processing industries (Gaskell and Smith, 2007).

Inorganic fertilizers are manufactured and mainly contain nitrogen (N), phosphorous (P), and potassium (K). Nitrogen is primarily provided by nitrogenous fertilizers as urea or ammonia fertilizers. Further shares of nitrogen are contained in complex fertilizers that combine all three plant nutrients (NPK) (Savci, 2012).

Fertilizers industry is one of the most important and large industries in Egypt in which several chemical processes beside physical operations take place. Several Egyptian companies are producing two basic types of fertilizers, which include nitrogenous and phosphate fertilizers (Egyptian Environmental Affairs Agency, 2002).

During manufacturing of fertilizers, workers may be exposed to several occupational accidents (Khan et al., 2006). Occupational accidents include workers entangled in rotating machinery, struck by moving machine components or run over by mobile equipment, falls, handling accidents, falling objects from inadequately protected elevated working places, electrical, explosion or burning accidents, and accidents by splash of chemicals (Calvin and Joseph, 2006).

Occupational injury is generally defined as ‘’an injury arising out of or in the course of employment resulting from the action of a physically or chemically traumatizing agent’’ (Lez, 1995).

Occupational injuries result from a complex interplay of multiple risk factors. Exposure to physical, mechanical and chemical hazards and the performance of unsafe practices by workers are the leading causes of occupational injuries. Similarly, psychosocial factors, work arrangements, socio-demographic characteristic of workers, environmental and social conditions are other potential risk factors (Tadesse T, Kumie, 2007).

As occupational accidents and injuries are one of the important problems among workers in fertilizers industry, and to the best of our knowledge, studies that have investigated the frequency of occupational accidents, injuries and their possible risk factors in the fertilizer industry in Dakahlia Governorate, Egypt are deficient.

Aim of work

To estimate frequency and severity rates of occupational injuries and describe their pattern and possible risk factors.

Materials and methods

- **Study design:** It comprised two parts; part I which was a record-based study of occupational injuries during a period of three years (2010 to 2012) and part II which was a case-control study of the injured workers and a control group of workers who did not experience occupational injuries during the same period.

-**Place and duration of study**: The study was conducted on workers of Delta Fertilizers and Chemicals Company at Talkha city, Egypt from November 1, 2013 to July 30, 2014.

-Study sample:

Part I: Among 3800 workers, 211 cases had history of one occupational injury and 16 cases had history of two injuries during the period 2010-2012. So, a total of 243 occupational injuries among 227 workers were recorded.

Part II: The study included two groups:

1. The injured group: Out of the 227 workers with occupational injuries, 65 workers were excluded from the study as one died, 27 retired, and 37 are not currently working at the company. So, 162 injured workers who were eligible to participate in the study.
2. The non-injured group: It comprised 162 non-injured workers from the same company and matching the injured group in most of the variables except for having occupational injuries. They were selected by systematic random sampling approach every 20th worker.

Job description of workers:

Work at the company is divided into three shifts; a morning shift from 7 am

to 3 pm, an evening shift from 3 pm to 11 pm, and a night shift from 11 am to 7 am. They work for eight hours per day. Work involves the use of a number of chemicals such as ammonia, nitric acid, ammonium nitrate, urea, and CO2 and machinery such as reactors, furnaces, pipes, valves, boilers, cooling drums, coating drums, prilling towers, holders and welding machines.

-Study methods:

Part I: A record sheet was provided by the Occupational Safety and Security Department at the company to obtain the required data from a master sheet which is formulated according to rules of the Egyptian Ministry of Manpower and Immigration (2003).

Part II: Each participant was interviewed to inquire about socio-demographic characteristics; occupational profile of workers; medical condition of workers; health and safety measures at work; injury profile; and finally job strain which was measured using job strain index (Theorell et al., 1998).

-The interview was carried out at the head of departments' offices at the company during the work day without interruption of the working schedule. Each questionnaire was completed within the range of 15 to 20 minutes with the participation of an average of 10 subjects/ setting.

Consent

An informed verbal consent of study subjects to participate in the study was obtained before the start of work with assurance of confidentiality and anonymity of the data.

Ethical approval

Approval of the administrative authority of the Company was obtained.

Study protocol was approved by Ethical Research Committee of Faculty of Medicine, Mansoura University.

Data Management

Calculating the injury rates was done according to the following formulas: (Egyptian Ministry of Manpower and Immigration, 2003)

$$\text{Frequency rate} = \frac{\text{total number of injuries}}{\text{total workers} \times \text{working days} \times \text{working hours/day}} \times 1000{,}000$$

$$\text{Severity rate} = \frac{\text{total number of days lost}}{\text{total workers} \times \text{working days} \times \text{working hours/day}} \times 1000{,}000$$

Data were entered and statistically analyzed using the Statistical Package

for Social Sciences (SPSS) version 17. Qualitative data were described as numbers and percentages. $\chi 2$ test or fisher's exact test was used for comparison between groups, as appropriate. Quantitative data were described as means ± (SD) or medians, as appropriate. They were tested for normality by Kolmogorov-Smirnov test. In the normally distributed variables, independent sample t-test was used; while in non-normally distributed variables, Mann Whitney test was used for comparison between groups. Binary logistic regression analysis was used for prediction of independent variables of occupational injuries. Significant predictors in the univariate analysis were entered into the regression model. Odds ratios and their 95% confidence interval were calculated. ''p value ≤0.05'' was considered to be statistically significant.

Results

Part I: Results of the record-based study

Table (1): Numbers, frequency and severity rates (per million person hours worked) of occupational injuries during the period 2010 - 2012.

Year	No.	Frequency rate		Severity rate	
		1st 6 Ms*	2nd 6 Ms*	1st 6 Ms*	2nd 6 Ms*
2010	69	8.6	9.34	304	432.7
2011	90	10.98	14.85	490.17	517.75
2012	84	9.1	14.85	286.12	592.22

* Ms: months

Table (1) showed that the year 2011 had the highest frequency (90) of occupational injuries and the year 2010 was the least (69). Frequency and severity rates in the first six months were highest in the year 2011 (10.98 & 490.17, respectively) while in the second six months, they were highest in the year 2012 (14.85 & 592.22, respectively).

As regards socio-demographic characteristics of injured workers, it was found that, the majority (98.4%) of injured workers were males and (61.9%) of them were ≤ 50 years with a mean age of (41.3 ± 12.7) years and a median duration of employment of 108 (1 444) months (Data are not shown in tables).

Occupational accidents occurred most frequently in the nitrate and urea production sectors (39.8% and 31.3%, respectively) followed by welding and mechanical workshops (8.5%) (Data are not shown in tables).

Table (2): Mechanism, cause, timing, and nature of occupational injuries.

Injury characteristics	N=243	
	No.	(%)
Mechanism		
Fall of persons	107	44.0
Fall of objects	32	13.2
Striking objects	29	11.9
Crush between objects	15	6.2
Overload and awkward posture	8	3.3
Temperature extremes	16	6.6
Electric shock	2	0.8
Harmful chemicals	34	14.0
Cause		
Mechanical instruments	18	7.4
Lifting and transport	43	17.7
Dangerous devices and instruments	17	7.0
Hazardous material and radiation	31	12.8
Work environment	133	54.7
Harmful microbes	1	0.4
Timing according to shift	**N=165**	
	No.	**(%)**
Morning	124	75.2
Evening	23	13.9
Night	18	10.9
Nature of injuries	**N=243**	
	No. (%)	
Fractures	39	16.0
Dislocations	2	0.8
Sprains and strains	31	12.8
Tears (ligament-nerve)	24	9.9
Amputation	1	0.4
Impact and internal injuries	6	2.5
Superficial wounds	24	9.9
Bruises and contusions	42	17.3
Burns and execution	33	13.6
Other multiple wounds	18	7.4
Suffocation	3	1.2
Foreign body	11	4.5
Others unidentified	9	3.7

Table (2) : showed that, fall of persons was the most frequent mechanism (44%); work environment was the most frequent cause (54.7%); and about three quarters (75.2%) of occupational injuries occurred in the morning shift. Abrasions and contusions (17.3%) and fractures (16%) were the most frequent nature of occupational injuries.

Part II: Results of the case control study

Socio-demographic and occupational profiles of the study groups revealed that the group of injured workers matched non-injured workers in most of the socio-demographic characteristics. All occupational profile items were statistically non-significant between both groups except for having past jobs where (53.1%) of injured workers had past other jobs compared to (70.4%) of non-injured workers (Data are not shown in tables).

Table (3): Job demands, decision latitude and strain among the study groups.

Parameter	Injured workers N=162		Non-injured workers N=162		Test of significance
	No.	(٪)	No.	(٪)	
Job demands					
High (≤13) Low (>13)	147 15	90.7 9.3	133 29	82.1 17.9	$\chi^2 = 5.2$, p≤0.05* OR 2.1 (1.1 - 4.4)
Decision latitude					
High (≤18) Low (>18)	33 129	20.4 79.6	45 117	27.8 72.2	$\chi^2 = 2.4$, p>0.05 OR 0.7 (0.4 - 1.2)
Job strain					
Present Absent	118 44	72.8 27.2	97 65	59.9 40.1	$\chi^2 = 6.1$, p≤0.05* OR 1.8 (1.1 - 2.9)

*: Significant

Table (3): showed that job demands, most of injured workers (90.7%) and (82.1%) of non-injured workers had high job demands with statistically significant difference between them (p≤0.05). About 80% of injured workers had low decision latitude compared to (72.2%) of non-injured workers. A higher percentage of

injured workers (72.8%) were found to have job strain compared to (59.9%) of non-injured workers with statistically significant difference between them (p≤0.05) (Table 3).

Table (4): Personal protective equipment usage among the study groups.

Equipments	Injured workers N = 162						Non-injured workers N = 162						Test of significance
	Always		Sometimes		No		Always		Sometimes		No		
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	
Gloves	4	2.5	50	30.8	108	66.7	32	19.8	56	34.5	74	45.7	$\chi^2 = 28.4$, p≤0.001*
Boots	110	67.9	22	13.6	30	18.5	125	77.2	15	9.3	22	13.6	$\chi^2 = 3.5$, p>0.05
Helmets	52	32.1	63	38.9	47	29.0	88	54.3	32	19.8	42	25.9	$\chi^2 = 19.6$,* p≤0.001
Goggles	2	1.2	10	6.2	150	92.6	5	3.1	12	7.4	145	89.5	$\chi^2 = 1.5$, p>0.05
Face mask	0	0.0	55	34.0	107	66.0	3	1.9	72	44.4	87	53.7	$\chi^2 = 7.3$,* p≤0.05
Uniform	137	84.5	4	2.5	21	13.0	139	85.8	3	1.9	20	12.3	$\chi^2 = 0.2$, p>0.05
Ear protectors	1	0.6	2	1.2	159	98.2	1	0 .6	12	7.4	149	92.0	$\chi^2 = 7.5$,* p≤0.05

*: Significant

Table (4) : showed that stated that, (66.7%) of injured workers didn't use gloves compared to (45.7%) of non-injured workers with highly statistically significant difference between both groups (p≤0.001). About 32% of injured workers always used helmets compared to (54.3%) of non-injured workers with highly statistically significant difference between them (p≤0.001). About half of non-injured workers and (66%) of injured workers didn't use face mask with statistically significant difference between both groups (p≤0.05).

Table (5): Logistic regression analysis of independent predictors of occupational injuries.

Independent predictors	β	p	OR (95% CI)
Job strain			
Present	0.6	p≤0.05*	1.9 (1.1 - 3.6)
Absent (r)			
Past jobs			
No	0.7	p≤0.01*	1.9 (1.2 - 3.3)
Yes (r)			
Gloves			
No	2.04	p≤0.001*	7.7 (2.5 - 24.2)
Sometimes	1.7	p≤0.01*	5.3 (1.7 - 16.3)
Always (r)			
Helmet			
No	0.3	P>0.05	1.3 (0.7 - 2.6)
Sometimes	0.9	p≤0.01*	2.4 (1.3 - 4.4)
Always (r)			
Constant	-2.7		
Model	54.1, p≤0.001		
% correctly predicted	65.4%		

r = reference group

*: Significant

Table (5): showed that having job strain, absence of past jobs, none using of gloves, and sometimes using of gloves and helmet were independently associated with the likelihood of having occupational injuries (OR= 1.9, 1.9, 7.7, 5.3, and 2.4, respectively).

Unsafe mechanical instruments and dangerous materials and radiation were the main reasons of occupational injuries reported by workers (95.1% and 80.2%, respectively). Good housekeeping and using PPE were the main preventive measures of occupational injuries recommended by the majority of workers (99.4% and 98.8%, respectively) (Data are not shown in tables).

Discussion

Occupational injuries are one of the leading causes of morbidity and mortality among workers. Many workers suffer occupational injuries that result in lost working hours, medical treatment, restriction of work or motion, and transfer to another job (Jaiswal, 2012).

In our study, frequency and Severity rates in the first six months were highest in the year 2011 (10.98 & 490.17, respectively) while in the second six months, they were highest in the year 2012 (14.85 & 592.22, respectively). However, the frequency rate of occupational injuries in six months was 0.1 and severity rate in the same period was (18.7) in the conversion industries in Ismalia, Egypt. This might be due to variation in workplace, technology, and environmental conditions (Fiala et al., 1998).

In our study, it was found that the year 2011 had the highest frequency (90) of occupational injuries and the year 2010 was the least (69). However, in a survey of a chemical company in Eastern India, it was found that there was a decreasing frequency of occupational injuries over a period of five years (Saha et al., 2008).

The results of this study showed that, (61.9%) of injured workers were ≤ 50 years with a mean age of (41 ± 12.7) years and the majority (98.4%) of them were males. Similarly, the mean age of injured workers admitted to hospital in two areas of southern China was (41.9 ± 11.5) years (Li et al., 2012).

These findings were in agreement with that of the study of occupational injuries of workers from two underground coal mines in the southern part of India, in which the mean age of injured workers was (43.3 ± 6.8) years (Kunar et al., 2008). Also, the mean age of injured workers in a chemical company in Eastern India was (35 ± 11.7) years (Saha et al., 2008).

In the study of occupational hazards in four Egyptian foundries, two in Alexandria, and two in El-Behira, it was found that, the age groups (31-40) and (41-50) had the highest incidence rate of injury. On the other hand, age group (51-60) had the lowest incidence rate of injury (Zakaria et al., 2005). This might be attributed to the work nature of workers in the age category of (51- 60

years) who were among the first hand supervisors and rarely encountered in the practical part of the work. The study of records from the Thailand National Injury Surveillance (NIS) System collected during 2001 - 2004, focusing on 17538 occupational injuries in Thailand, reported that (85%) of injured workers were males (Thepaksorn et al., 2007). Similarly, the majority of injured workers of Seven Up Bottling Company (92.8%) were males (Joel, 2006). Also, in the study of work stressors in relation to work-related non-fatal injuries of petrochemical workers in Taiwan, it was found that (90.3%) of injured workers were males (Li et al., 2001).

This could be attributed to the work nature of males who perform high-risk tasks or occupations such as machine operation which might make injury risk higher for males compared to females (Ince et al., 2006). This was the situation in our study where occupational accidents occurred most frequently in the production sectors (71.1%) followed by welding and mechanical workshops (8.5%). This finding was in accordance with that of the study conducted among workers of Seven Up Bottling Company, in which, the production departments had the highest number of occupational accidents (57.3%) (Joel, 2006).

Similarly, it was reported that (40%) of injured workers, in a fertilizer producing industry in eastern India, were involved in the production division followed by the maintenance division (29%). This might be explained by the presence of hazardous materials, mechanical instruments, and dangerous devices and instruments in the production departments (Saha et al., 2004).

Our study revealed that fall of persons was the most frequent mechanism of occupational injuries (44%) followed by harmful chemicals (14%) and fall of objects (13.2%). Our findings were in accordance with that of the study of occupational injuries in the conversion industries in Ismalia, Egypt, in which fall of persons and fall of objects were the most frequent mechanisms of occupational injuries (Fiala et al., 1998). Similarly, accidental falls and falling objects were the most frequent mechanisms of occupational injuries admitted to the emergency room at the University Hospital Groningen, Netherlands (Kingma, 1994).

This study showed that work environment was the most frequent cause of occupational injuries (54.7%) followed by lifting and transport (17.7%), while harmful microbes was the least frequent (0.4%). Similarly, work environment and lifting and transport were the major causes of occupational injuries while biologic agents were not responsible for any in two foundries in Alexandria and two in El-Behira (Zakaria et al., 2005).

The study showed that most of occupational injuries (75.2%) occurred in the morning, and least frequently (10.9%) at night shift. These findings were in close agreement with that conducted among personnel of Natural Gas Fertilizer Companies in Bangladesh where most of occupational injuries (57.14%) occurred in the morning shift, and the least frequency (8.34%) was in the night shift (Khan et al., 2006).

Similarly, in two studies in Turkey; occupational injuries admitted to the emergency department at a university-based hospital in Edirne occurred mostly in the morning shift (Sayhan et al., 2013), and in the study of occupational hand injuries treated at tertiary care facility in western Turkey, it was found that, the highest frequency was also observed in the morning shift. The tendency of occupational accidents to occur more frequently during the morning shift may be due to the hurry of some workers to finish their work before lunch break and that workers begin to work without enough focus or adaptation to working environment (Serinken et al., 2008; Kifle et al., 2014).

This study showed that, the most frequent occupational injuries were abrasions and contusions (17.3%) followed by fractures (16%), while amputation was the least frequent (0.4%). These findings were in accordance with the findings of the study of workers in metallurgical factory in the State of São Paulo, southeastern Brazil where abrasions and contusions (31.2%) were the most frequent occupational injuries followed by fractures (14%), while amputation was the least frequent (1.1%) (Cordeiro, 2002). Similarly, in Ethiopia, abrasions, fractures, burns, cuts, and punctures were the most common injury types among manufacturing industrial workers engaged in small and medium-

scale industries (Tadesse and Kumie, 2007).

The study showed that, (53.1%) of injured workers had past other jobs compared to (70.4%) of non-injured workers with statistically significant difference between both groups. This was similar to the results of Egyptian study of construction workers, where (32.6%) of injured workers had an experience of ten years or more compared to (67.4%) of non-injured workers with statistically significant difference between them (Abbas et al., 2013). This might be attributed to the more experience gained by the engagement in past other jobs which decreases the risk of occupational injuries.

The present study showed that, most of injured workers and non-injured workers had high job demands with statistically significant difference between them; (79.6%) of injured workers had low decision latitude compared to (72.2%) of non-injured workers; and a higher percentage of injured workers (72.8%) were found to have job strain compared to (59.9%) of non-injured workers with statistically significant difference between them. Similarly, (64.9%) of injured workers had job strain compared to (35.1%) of non-injured construction workers in Dakahlia Governorate, Egypt with statistically significant difference between them (Abbas et al., 2013). This might be due to physiological and psychological alterations resulting from job strain that may increase the likelihood of developing physical and mental problems. These conditions may increase the risk of sustaining more occupational injuries among industrial workers (Li et al., 2001).

As regards workers' usage of PPE, it was found that, (66.7%) of injured workers didn't use gloves compared to (45.7%) of non-injured workers. Majority of both injured and non-injured workers didn't use goggles and ear protectors. About (66%) of injured workers and about half of non-injured workers didn't use face mask, while most of both injured and non-injured workers (67.9% and77.2%, respectively) always used boots, the majority of both injured and non-injured workers (84.5% and 85.8%, respectively) always used uniform, and

(32.1%) of injured workers always used helmets compared to (54.3%) of non-injured workers.

In Nigeria, (85.5%) of paint factory workers didn't use gloves, (61.5%) didn't use goggles, while (25.5%) of them used boots, and (28%) used uniform (Awodele et al., 2014). This could be attributed to an insufficient supply of PPE, lack of awareness, worker's discomfort from PPE, and lack of complying with safety rules.

Logistic regression analysis in our study revealed that, having job strain, absence of past jobs, non using of gloves, and sometimes using of gloves and helmet were independently associated with the likelihood of having occupational injuries (OR= 1.9, 1.9, 7.7, 5.3, and 2.4, respectively). Similarly, in Korea, , it was found that having job strain was independently associated with the likelihood of having occupational injuries among employees in small to medium sized manufacturing enterprises (OR=1.7) (Kim et al., 2009). In Ethiopia, two studies reported similar findings where experience of five years or below was independently associated with the likelihood of having occupational injuries among workers engaged in small and medium-scale industries (OR=1.5) and non use of PPE increased occurrence of occupational injuries among workers in iron and steel industries (OR=3.5) (Tadesse and Kumie, 2007; Kifle et al., 2014).

In this study, unsafe mechanical instruments and dangerous materials and radiation were the main reasons of occupational injuries reported by workers. Similarly, in India, unsafe mechanical instruments and dangerous materials were the main reasons of occupational injuries reported by (48.2% and 51.4%, respectively) of injured workers and (24.2% and 19.7%, respectively) of non-injured workers from two underground coal mines (Kunar et al., 2008).

The study results showed that, good housekeeping and using PPE were the main preventive measures recommended by workers. Similarly, they were the main preventive measures of occupational injuries recommended by the majority of workers in iron and steel industries, Ethiopia (Kifle et al., 2014).

Conclusion and Recommendations

Workers in Delta Fertilizers and Chemicals Company face many occupational injuries. Fall of persons was found to be the most frequent mechanism; working environment was the most frequent cause; and abrasions and contusions were the most frequent nature of occupational injuries. Having job strain, absence of past jobs, non-using of gloves, and sometimes using of gloves and helmets are independently associated with having occupational injuries.

The studied occupational injuries could be ameliorated through environmental, administrative and personal measures by the implementation of an effective occupational health and awareness programs that should be monitored and reviewed regularly.

Conflict of interest

None.

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