

OCCUPATIONAL INJURIES IN CHEMICAL INDUSTRY

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The aim of that paper is to examine the nature of the injury problem in relation to age and sex of the victims, to estimate the type and consequences of occupational injuries, particularly in terms of lost working days and to identify the way in which they occur. Male workers have a slightly higher injury rate than female workers. Leading causes of injuries over the examined ten years period were: being struck by flying or falling objects, collision and being compressed by mechanical or other objects and equipment. These injuries resulted in an average of 69.1 ± 10.9 lost workdays per injured worker. The sprains and lacerations were statistically significant and more frequently presented in female than in male workers. Ruptures of internal organs, fractures and ruptures and tears of joints and ligaments resulted in 100 or more lost workdays for each worker. The number of days off work rose proportionally to the age of the victims. Chemical industry presents one of the more hazardous industry. These results are important for the control and prevention of occupational injuries. *Acta Medica Medianae* 2004; 43 (2): 29–35.

Key words: occupational injuries, occupational accidents, chemical industry

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Introduction

Occupational injury is any personal injury, physical damage to body tissues or death from an occupational accident. Occupational injuries are responsible for more lost working-time, productivity, and working years of life than any other health conditions. Injuries are the leading cause of morbidity and mortality among the workers. Thousands of people are annually killed in industrial accidents, and the number of disabling injuries is also staggering in figures. Many workers suffered job related injuries that resulted in lost working time, medical treatment, loss of consciousness, restriction of work or motion, or transfer to another job. Today injuries continue to claim the lives, damage the physical and psychological well-being and consume the resources of workers and their families. The overall human, social, and financial toll of traumatic occupational injury is enormous, rivaling the burden imposed by such health threats as cancer and cardiovascular disease (1,2,3). The direct cost (lost wages, medical and rehabilitation payments, insurance administrative costs, property losses, production losses) plus indirect costs (cost associated with pain and suffering by workers and family members) of occupational injuries were estimated to be about \$ 30

billion annually (4). Intrajob workload, psychosocial factors and organizational factors are potential risks for work related injuries (5). Machinery related injuries were the second leading cause of traumatic occupational fatalities (6).

Aim

Occupational injury rate in chemical industry, between 1993 and 2002 has been analyzed. It was undertaken to examine the nature and the magnitude of the injury problem in relation to the age and sex of the victims, to estimate the type and consequences of occupational injuries, particularly in terms of the lost day and to identify the way in which they occur, as a basis for planning preventive measures.

Methodology

The number of occupational injuries followed by the absence from work has been estimated. This paper presents a descriptive analysis of occupational injuries involved in chemical industry over a ten year period. An injury was defined as occupational if it occurred while working for compensation, on or out of employer's premises, while arriving or leaving work, on a break, if on employer's premises, or working as a volunteer. All injuries, which have resulted in at least one day's absence from work after the day of the injury formed the basis of the analyses. When the injury occurs, data are entered by management representatives

of the safety department and the plants medical staff. The data set includes information on employee's characteristics (e.g. sex, age, and education), characteristics of the workplace and event, description of the injury (injury type and injured body part) and outcome (lost days, days on which employees reported to work but were assigned to light or alternative duties). All analyzed injuries must have met one or more of the following conditions: medical treatment required loss of consciousness, restriction of work or motion, transfer to another job or resulted in death. The circumstances of each incident were reviewed using variables in the database, including the narrative description of "how the injury occurred", the nature of the injury, the injured workers job title, and recommendations to prevent future occurrences. External cause of injury in database was based on codes from the International Classification of Diseases (7), excluding only suicide and medical misadventure. Injuries were classified in terms of the general environment in which they occur, the general mechanisms of injury (motor vehicle collisions, falls etc.), or the contributing behavioral of human factor. For annual injury rate calculation the number of injuries was divided by average number of employed workers in that year and multiplied by 100.

Data were analyzed using the Statistical Packing for the Biomedical Sciences.

Results

Annual injury rate per 100 workers in the chemical industry was the lowest in 1994 (2.01 per 100 workers) and the highest in 1997 (5.71 per 100 workers). The greatest number of traumatic occupational injuries among the male occurred in 1998 (8.2 per 100 male workers). The highest injury rate among the females was in 1997 (4.78 per 100 female workers). Male workers have a slightly higher injury rate than female

workers (table 1). During the examined period, 502 workers have been injured as a result of occupational accidents. Fifty eight percent of the injured workers were males. Leading causes of injuries over that ten year period were: being struck by flying or falling objects, collision and being compressed by mechanical or other objects and equipments. Leading causes of injuries among the male workers were traffic accidents and collision. Leading causes of occupational injuries among females were electrocution and being compressed by objects or equipment. The difference between male and female was statistically significant (table 2). Lower and upper extremities were the most frequently injured parts of the body. The injuries of head, upper and lower extremities were statistically significant more frequently presented in male than in female (table 3). These injuries resulted in 34 688 lost workdays, averagely 69.1 ± 10.9 days per an injured worker. The injuries of internal organs, lower and upper extremities resulted in 70 or more lost workdays for each worker. The differences in the average number of lost workdays between male and female workers were statistically significant (table 4). The most common type of injuries was contusions, closed fractures and lacerations. The sprains and lacerations were statistically significant, frequently presented in female than in male workers. Fractures and burns were statistically significant, frequently presented in male than in female workers (table 5). Ruptures of internal organs, fractures and ruptures and tears of joints and ligaments resulted in 100 or more lost workdays for each worker. The sprains and contusions resulted in statistically significant more lost workdays among female than in male workers (table 6). The prevalence of all types of injuries decreased in relation to the education level of the victims (table 7). The prevalence of contusions and burns decreased along with the age of the victims. The prevalence of the closed fractures, sprains, ruptures and tears of joints and ligaments increased along with the

Table 1. Annual injury rate in chemical industry

Year	Male		Female		Total	
	Number	Rate	Number	Rate	Number	Rate
1993	18	2.43	13	1.83	31	2.14
1994	17	2.26	12	1.73	29	2.01
1995	26	3.56	19	2.62	45	3.09
1996	37	5.10	28	3.87	65	4.49
1997	47	6.68	35	4.78	82	5.71
1998	58	8.20	12	1.64	70	4.86
1999	21	3.08	15	2.04	36	2.54
2000	24	3.28	17	2.49	41	2.90
2001	22	3.29	29	4.41	51	3.85
2002	23	3.27	29	4.25	52	3.75

Table 2. Causes of injuries by sex

Causes	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
Fall from height	2	28.6	5	71.4	7	100.0
Fall on some level	39	67.2*	19	32.7	58	100.0
Compressed by mechanical or other object and equipment	38	38.4	61	61.6*	99	100.0
Traffic accidents	18	85.7*	3	14.3	21	100.0
Struck by flying or falling objects	73	58.9*	51	41.1	124	100.0
Collision	75	73.5**	27	26.5	102	100.0
Electrocution	5	21.7	18	78.3*	23	100.0
Eruption or explosion	19	51.3	18	48.6	37	100.0
Poisoning	24	77.4*	7	22.6	31	100.0
Total	293	58.4**	209	41.6	502	100.0

Statistical comparisons between male and female

* p<0.05

**p<0.01

Table 3. Involved body by sex of the victims

Part of body	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
Head	34	82.9*	7	17.1	41	100.0
Eye	18	62.1	11	37.9	29	100.0
Neck	6	60.0	4	40.0	10	100.0
Internal organs	3	33.3	6	67.7	9	100.0
Upper extremities	104	59.4*	71	40.6	175	100.0
Lower extremities	117	58.2*	84	41.8	201	100.0
Multiple sites	11	29.7	26	70.3*	37	100.0
Total	293	58.4**	209	41.6	502	100.0

Statistical comparisons between male and female

* p<0.05

**p<0.01

Table 4. Involved body part by day off work

Part of body	Male		Female		Total	
	X	SD	X	SD	X	SD
Head	39.7***	2.1	26.3	2.7	37.4	2.5
Eye	32.4**	2.9	25.4	2.1	29.7	2.4
Neck	37.9*	4.5	28.1	3.2	33.9	3.7
Internal organs	151.3	10.3	134.8	11.9	140.0	12.9
Upper extremities	84.3***	7.2	57.1	3.9	73.3	4.5
Lower extremities	90.2	10.4	61.2	8.7	78.1	9.3
Multiple sites	85.4***	7.5	46.7	3.2	58.2	4.9
Total	78.1***	11.2	56.4	10.7	69.1	10.9

* p<0.05

** p<0.01

***p<0.001

Table 5. Type of injuries by the sex

	Male		Female		Total	
	Number	Percent	Number	Percent	Number	Percent
Contusions	131	66.5**	66	33.5	197	100.0
Lacerations	14	22.9	47	77.0**	61	100.0
Closed fractures	56	86.1**	9	13.8	65	100.0
Open fractures	28	90.3**	3	9.7	31	100.0
Sprains	3	5.8	49	94.2**	52	100.0
Ruptures and tears of joints and ligaments	21	45.6	25	54.3	46	100.0
Ruptures of internal organs	1	25.0	3	75.0	4	
Burns	36	87.8**	5	12.2	41	
Poisoning	3	60.0	2	40.0	5	100.0
Total	293	58.4**	209	41.6	502	100.0

Statistical comparisons between male and female

* p< 0.05

**p<0.01

Table 6. Type of injury by day away from work

	Male		Female		Total	
	X	SD	X	SD	X	SD
Contusions	10.8	3.1	12.1*	2.9	11.2	3.1
Lacerations	21.8	4.2	23.7	3.7	23.3	3.9
Closed fractures	184.7	21.2	192.3	20.3	185.7	21.1
Open fractures	197.4	19.9	201.7	21.2	197.8	20.7
Sprains	73.2	4.7	79.4*	3.9	79.1	4.1
Ruptures and tears of joints and ligaments	98.5	14.1	102.3	12.3	100.6	13.2
Ruptures of internal organs	195	0.0	208.7	21.3	205.3	21.6
Burns	74.8	4.7	77.4	3.9	75.1	4.2
Poisoning	37.7	2.3	42.1	2.8	39.5	2.7
Total	78.1***	11.2	56.4	10.7	69.1	10.9

Statistical comparisons between male and female

* p<0.05

***p<0.001

age of the victims (table 8). Workers 41 years of age and older had the most average lost workdays (more than 100 days off work). The number of days away from work rose the age of the victims (table 9).

Discussion

Here we report on the epidemiology of occupational injuries occurring in chemical industry from 1993 to 2002. Injury certificate data identified 502 chemical workers who were injured in occupational accidents over the examined period. The circumstances of these 502 injuries provide valuable infor-

mation that can be used to prevent occupational injuries in chemical industry. During a period of ten years the average annual rate of occupational accidents has not gone through a significant drop despite some structural, technological changes and organizational transformations in the plant.

Our analysis showed that male workers were consistently at higher risk. These results are similar to the results cited in literature (8). This paper showed that injuries of head, eyes, neck, upper and lower extremities, especially fractures were statistically significant, more frequently presented in male than in female workers. The sprains were statistically significant and frequently presented among the females. Our results

Table 7. Type of injury by the education level of the victims

Type of injury	Primary school		Secondary school		High school		College level		Total	
	N	%	N	%	N	%	N	%	N	%
Contusions	71	36.0	58	29.4	43	21.8	25	12.7	197	100
Lacerations	19	31.1	17	27.9	16	26.2	9	14.7	61	100
Closed fractures	42	64.6	17	26.1	4	6.1	2	3.1	65	100
Open fractures	24	77.4	4	12.9	2	6.4	1	3.2	31	100
Sprains	40	76.9	7	13.5	3	5.8	2	3.8	52	100
Ruptures and tears of joints and ligaments	27	58.7	8	17.4	5	10.9	6	13.0	46	100
Ruptures of internal organs	3	75.0	1	25.0					4	100
Burns	34	82.9	7	17.1					41	100
Poisoning	4	80.0	1	20.0					5	100
Total	264	52.6	120	23.9	73	14.5	45	8.9	502	100

Table 8. Type of injuries by the age

Type of injury	Age (year)									
	Under 20		20-40		41-60		Over 60		Total	
	N	%	N	%	N	%	N	%	N	%
Contusions	91	46.2	59	29.9	24	12.2	23	11.7	197	100
Lacerations	15	24.6	17	27.9	16	26.2	13	21.3	61	100
Closed fractures	5	7.7	4	6.2	27	41.5	29	44.6	65	100
Open fractures	4	12.9	2	6.4	13	41.9	12	38.7	31	100
Sprains	11	21.1	12	23.1	15	28.8	14	26.9	52	100
Ruptures and tears of joints and ligaments	3	6.5	3	6.5	19	41.3	21	45.6	46	100
Ruptures of internal organs			1	25.0	1	25.0	2	50.0	4	100
Burns	24	58.5	15	36.6	1	2.4	1	2.4	41	100
Poisoning	4	80.0	1	20.0					5	100
Total	157	31.3	114	22.7	116	23.1	115	22.9	502	100

are similar to the other authors who found that the highest incidence rates among men were fractures, among women the highest rates were for those of sprains. The other authors found that injury rates were more than twice as high in young men as in young women and that this difference declined with increasing in age (9). Gender differences in injury rates might be explained by differences in workplace exposure (10).

Leading causes of injuries were collisions, being struck, being compressed by object and equipment and falls. These results are similar with the literature data (9,11,12). Traffic accidents are the significant cause of occupational injuries, which is in accordance with the literature data (11, 13). Analysis

of 139 deaths in US female construction workers showed that female workers in transportation and material moving had a higher mortality rates than male construction workers in the same occupation from motor vehicles which was the leading cause of occupational injury death in women (14). Electrocution is a leading cause of injuries among the women which is in according to the other authors (12,15).

Upper and lower extremities were the most often affected body parties. Contusions, lacerations and closed fractures were the most frequent injury types. These findings are similar to the results of the other authors (16,17,18).

Table 9. Day off work by the age

Type of injury	Age (year)									
	Under 20		20–40		41–60		Over 60		Total	
	X	SD	X	SD	X	SD	X	SD	X	SD
Contusions	8.8	1.2	10.9	2.1	15.9	2.5	16.5	4.5	11.2	3.1
Lacerations	21.5	3.1	21.6	2.9	24.8	2.7	25.7	4.2	23.3	3.9
Closed fractures	135.6	14.2	139.2	17.8	192.1	22.5	194.8	22.1	185.7	21.1
Open fractures	171.0	7.5	173.9	9.1	202.7	20.5	205.4	23.2	197.8	20.7
Sprains	68.9	2.1	71.8	3.1	84.3	4.9	87.8	5.2	79.1	4.1
Ruptures and tears of joints and ligaments	72.7	5.9	75.4	9.8	98.7	12.3	109.9	15.1	100.6	13.2
Ruptures of internal organs			200.0	0.0	200.0	0.0	210.5	21.9	205.3	21.6
Burns	74.8	3.8	75.3	4.9	76.0	0.0	77.0	0.0	75.1	4.2
Poisoning	38.9	1.9	42.0	0.0					39.5	2.7
Total	34.5	5.2	38.4	4.9	103.6	10.8	111.8	11.4	69.1	10.9

Occupational accidents were associated with exceptionally severe injuries as reflected by the great number of lost workdays. These injuries resulted in 34 688 lost workdays, an average of 69.1 ± 10.9 days per injured workers. These results are similar to the other authors who found that 41 % injuries resulted in an employee missing work and incurred a total of 22730 lost workdays, an average of 61 days per lost workday incident (19).

One of the key finding in this study indicates that injury rates are highest among the youngest and the lost workdays are highest among the oldest. It has been well documented that age and accident rates are negatively related (probably because older workers are more experienced on their working place and have greater job knowledge, patience, and skills than younger counterparts). When injuries do occur, older workers are usually more severely hurt, and fatalities occur more frequently among older workers. Some of the possible reasons why younger workers may be so much affected by injury are: limited job knowledge, training, and skills, and perhaps less sense of responsibility. These factors all point to the importance of safety attitudes in performing safety at work. Older workers are more satisfied with job and more likely to assess general housekeeping and checking of safety equipment.

Older workers could be more knowledgeable and experienced, display more positive attitudes to safety, and possibly more committed to work than younger workers. Older workers are quite capable of learning safety regulations and safety system of work, and are willing to comply with safety regulations. Perhaps it is attributable to the fact that job knowledge structures increase with age and compensate for declines in ability. Perhaps the workers with working experience were more likely to hide lost days injuries that occurred (20, 21, 22,23). Our results showed that the risk and severity of occupational related traumatic injury was inversely related to worker age and educational level, which is similar to the literature data (16).

Conclusion

It should be acknowledged that chemical industry presents one of the more hazardous industry. Sex and age of the victims are significant contributing factors in the development of occupational injuries and their outcomes as well. All the above mentioned is important for the control and prevention of occupational injuries in chemical industry.

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POVREDE NA RADU U HEMIJSKOJ INDUSTRIJI

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Cilj ovog rada je analiza problema povreda na radu u odnosu na starost, pol, tip, posledice a posebno u odnosu na broj izgubljenih radnih dana. Muškarci su se nešto češće povređivali u odnosu na žene. Vodeći uzrok povređivanja u ispitivanom desetogodišnjem periodu su bili udarci objektima koji padaju ili lete, okliznuća i nagnječenja objektima ili sredstvima. Zbog povreda na radu je svaki povređeni radnik odsustvovao s posla prosečno 69.1 ± 10.9 radnih dana. Uganuća i razderne rane su statistički značajno češće kod žena nego kod muškaraca. Za svaku od povreda koje su dovele do ruptur unutrašnjih organa, frakture, ruptur ili rascepa mišića i ligamenata svaki povređeni radnik je izgubio preko 100 radnih dana. Broj izgubljenih radnih dana raste sa starošću povređenih radnika. Hemijska industrija predstavlja veoma opasnu i traumatogenu granu industrije. Rezultati ovoga rada mogu naći praktičnu primenu u kontroli i prevenciji povreda na radu. *Acta Medica Medianae* 2004; 43(2): 29–35.

Ključne reči: povrede na radu, nezgode na radu, hemijska industrija