

## PREVENTION OF OCCUPATIONAL ACCIDENTS

*Jovica Jovanovic*

Medical services, physicians and nurses play an essential role in the plant safety program through primary treatment of injured workers and by helping to identify workplace hazards. The physician and nurse should participate in the worksite investigations to identify specific hazard or stresses potentially causing the occupational accidents and injuries and in planning the subsequent hazard control program. Physicians and nurses must work closely and cooperatively with supervisors to ensure the prompt reporting and treatment of all work related health and safety problems.

Occupational accidents, work related injuries and fatalities result from multiple causes, affect different segments of the working population, and occur in a myriad of occupations and industrial settings. Multiple factors and risks contribute to traumatic injuries, such as hazardous exposures, workplace and process design, work organization and environment, economics, and other social factors. With such a diversity of theories, it will not be difficult to understand that there does not exist one single theory that is considered right or correct and is universally accepted. These theories are nonetheless necessary, but not sufficient, for developing a frame of reference for understanding accident occurrences. Prevention strategies are also varied, and multiple strategies may be applicable to many settings, including engineering controls, protective equipment and technologies, management commitment to and investment in safety, regulatory controls, and education and training. Research needs are thus broad, and the development and application of interventions involve many disciplines and organizations. *Acta Medica Medianae* 2004; 43 (1):49 – 55.

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### Background

Each year, occupational accidents result in staggering costs in terms of loss of life, pain and suffering, lost wages for the injured workers, damage to production facilities and equipment, and loss production opportunity. In 1948, workplace accidents in United States caused 11500 deaths, 1900000 disabling injuries, and over 40 million lost workdays. The estimated cost, including lost wages, medical and rehabilitation payments, insurance administrative costs, property losses, production losses, and other indirect costs was approximately \$ 33 bilion (1).

As result of the aggressive implementation of industrial safety programs, the annual rate of accidental industrial fatalities in the United States declined from about 33 per 100000 workers in 1945 to 11 per 100000 in 1984 (2). For these reasons, the prevention of industrial accidents continues to be a high priority in occupational health.

### Introduction

Occupational accident is an unexpected and unplanned occurrence, including acts of violence, arising out of or in connection with work which results in one or more workers incurring a personal, disease or death. As occupational accidents are to be considered travel, transport or road traffic accidents in which workers are injured and which arise out of or in the course of work, i.e. while engaged in an economic activity, or at work, or carrying on the business of the employer. As occupational accidents are to be considered an accident occurring on the habitual route, in either direction, between the place of work or work related training and the workers principal or secondary residence, the place where the worker usually takes his or her meals, or the place where he or she usually receives his or her remuneration, which results in death or personal injury.

Occupational injury is any personal injury, physical damage to body tissues or death from an occupational accident. Occupational injuries are responsible for more lost time from work, 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 killed annually in industrial accidents, and the number

of disabling injuries is also staggering figure. Many workers suffered job related injuries that resulted in lost work 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 treats as cancer and cardiovascular disease.

### Consequences of occupational accidents

Each year, occupational accidents result in staggering costs in terms of loss of life, pain and suffering, lost wages for the injured worker, damage to production facilities and equipment, and loss production opportunity. The direct cost (lost wages, medical and rehabilitation payments, insurance administrative costs, property loses, production loses) 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 (3). These figures underestimate the true count and cost of all work injuries, however, because of underreporting of non acute injuries by many industrial record keeping systems. Outcome studies have addressed time lost from work and cost of compensation, health, functional and family outcomes. Work related upper extremity cumulative trauma disorders result in persisting symptoms and difficulty in performing simple activities of daily living, impacting symptoms and difficulty in performing simple activities of daily living, impacting home life even more than work, job loss, symptoms of depression and family disruption were common (4).

Ulnar post traumatic aneurysms of the hand and shingles as a consequences of occupational injury have been previously reported in the medical literature (5, 6). Occupational accidents involving sharp instruments (needles, scalpels, scissors) are important because of their capacity of transmit through the blood serious pathogenically agents. At least 20 pathogens microorganisms can be transmitted via a needle stick injury (7). Post traumatic stress disorder, mood disorders, changes of emotional state, cognitive and psychosocial disabilities are the most common consequences of occupational accidents (8, 9). Occupational accidents are a major source of ocular trauma, which is represented by a wide spectrum of injuries with substantial morbidity and economic costs (10). Of the 913 non fatal injuries, 41% resulted in an employee missing work and incurred a total of 22730 lost workdays, an average of 61 days per lost workday incident (11). Musculoskeletal injuries are the predominant form of reported non fatal occupational injuries (12).

### Epidemiology of occupational accidents

Data on occupational accidents are not available from all countries in the world. The average estimated

fatal occupational accident rate in whole world was 14.0 per 100,000 workers (13). The rates are different for individual countries and regions and for separate branches of economic activity. The European Union rate was 5.89 per 100,000 workers. The highest rates (23.1 per 100,000 workers) are found in Asia. The rapidly industrializing countries such as the Republic Korea, Thailand, and Indonesia have reported high fatal accident frequency rates (13). United States annual fatality rate was 3.2 per 100,000 workers (14).

Certain industries such as mining agriculture, forestry and construction had the high rates of fatal accidents (15, 16). While non fatal accidents declined during last six decades the construction, agriculture, manufacturing, transportation, fishing industry and mining sectors continue to experience high rates of disabling injuries (14, 17). Agriculture is one of the most hazardous industries. Risk of agricultural injuries is approximately 5-10/100 persons a year, but is higher in certain risk groups, such as males and cattle workers. Falls, machinery and animals are among the most the most common causes (18). Unique features of agricultural workplace and exposed population, wide range of activities, hazards, dispersed workplaces in agriculture, a seasonal hired workforce that often has brief tenure, poor skills combine to increase risk for occupational injuries.

Examples of overt trauma and commonly affected occupational groups given in literature (19, 20, 21) are shown on table 1. Fractures, bruises, lacerations, contusions, penetration by foreign bodies and sprains or strains are the most frequent injury types. Fingers, hands, eyes, feet, arms and legs are most often affected (19, 22). Among the health care workers most reported incidents occurred on hospital wards. The most common incidents were needle stick injuries, and 35% occurred when the needle was recapped. Medical laboratory technicians and nurses reported significantly more mucocutaneous incidents than other professionals. In 10% of the incidents, the patient had a known blood borne infection. The majority of accidents occurred in operating theatres, and connection with anesthesia (23).

More injuries occurred on Monday and Thursdays, between 9 and 10 am (21). These peaks in incident frequency for a particular time of day may simply reflect a higher number of persons working at those times rather than changing incidence during the day. The peaks in incident times could also be the result of different operations being performed at different times of the day, or might be due to changes in worker behavior. The highest injury incidence rates are among the younger worker (14, 22, 24, 25, 26, 27). It has been well documented that age and accident rates are negatively related (probably because older workers are more experienced on the job 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 at increased of work related injury are limited job knowledge, training, and skills, and perhaps less sense of responsibility. These factors all point to the importance

Table 1. Examples of overt trauma and commonly affected occupational groups

| Cause             | Injury type                  | Affected occupations                                                                     |
|-------------------|------------------------------|------------------------------------------------------------------------------------------|
| Mechanical energy | Lacerations                  | Sheet metal workers, butchers, press operators, sawyers, fabric cutters                  |
|                   | Fractures                    | Materials handlers, miners, construction workers                                         |
|                   | Contusions                   | Materials handlers, any workers exposed to low energy impacts                            |
|                   | Amputations                  | Press operators, butchers, machine operators                                             |
|                   | Crushing injuries            | Materials handlers, press operators, construction workers, rubber workers                |
|                   | Eye injuries                 | Miners, grinders, saw mill operators, machine shop employees                             |
|                   | Strains /Sprains             | Materials handlers, miners, baggage handlers, mail handlers, construction workers        |
| Thermal energy    | Burns                        | Foundry workers, smelter workers, welders, glass workers, laundry workers                |
|                   | Heat strain                  | Firefighters, steel workers, smelter workers                                             |
|                   | Cold strain                  | Utility workers, lumberjacks, butchers                                                   |
| Chemical energy   | Burns                        | Masons, process workers, hazardous waste workers                                         |
|                   | Asphyxiation, Acute toxicity | Firefighters, confined space workers, hazardous waste workers                            |
| Electrical energy | Electrocution, shocks, burns | Utility workers, construction workers, electricians, users of electric tools or machines |
| Nuclear energy    | Radiation burns              | Hospital workers, industrial radiographers, nuclear workers                              |

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.

The risk of occupational related traumatic injury is inversely related to worker age and educational level (19).

### Accident causation

Occupational accidents, work related injuries and fatalities result from multiple causes. Many traditional theories about the causes of occupational accidents focus on the worker. Many attempts have been made to develop a prediction theory of accident causation, but so far none has been universally accepted. Researchers from different fields of science and engineering have been trying to develop a theory of accident causation which will help to identify, isolate and ultimately remove the factors that contribute to or cause accidents.

### Accident Causation Theories

#### *The domino theory*

According to domino theory, 88% of all accidents are caused by unsafe acts of people, 10% by

unsafe actions and 2% by „acts of God“. It proposed a „five-factor accident sequence“ in which each factor would actuate the next step in the manner of toppling dominoes lined up in a row. The sequence of accident factors is as follows:

1. ancestry and social environment,
2. worker fault,
3. unsafe act together with mechanical and physical hazard,
4. accident, and
5. damage or injury.

In the same way that the removal of a single domino in the row would interrupt the sequence of toppling. Removal of one of the factors would prevent the accident and resultant injury, with the key domino to be removed from the sequence being number 3. Although the author provided no data for his theory, it nonetheless represents a useful point to start discussion and a foundation for further research.

#### *Multiple causation theory*

Multiple causation theory is an outgrowth of the domino theory, but it postulates that for a single accident there may be many contributory factors, causes and sub-causes, and that certain combinations of these give rise to accidents. According to this theory, the contributory factors can be grouped into the following two categories:

1. Behavioral factors, which include factors pertaining to the worker, such as improper attitude, lack of skills knowledge, lack of and inadequate physical and mental condition.

2. Environmental factors, which include improper guarding of other hazardous work elements and degradation of equipment through use and unsafe procedures.

The major contribution of this theory is to bring out the fact that rarely, if ever, is an accident the result of a single cause or act.

#### *The pure chance theory*

According to the pure chance theory, every one of any given set of workers has an equal chance of being involved in an accident. It further implies that there is no single discernible pattern of events that leads to an accident. In this theory, all accidents are treated as acts of God, and it is held that there exist no interventions to prevent them.

#### *Biased liability theory*

Biased liability theory is based on the view that once a worker is involved in an accident, the chances of the same worker becoming involved in future accidents are either increased or decreased as compared to the rest of workers. This theory contributes very little, if anything at all, towards developing preventive actions for avoiding accidents.

#### *Accident proneness theory*

Accident proneness theory maintains that within a given set of workers, there exists a subset of workers who are more liable to be involved in accidents. Researchers have not been able to prove this theory conclusively because most of the research work has been poorly conducted and most of the findings are contradictory and inconclusive. This theory is not generally accepted. It is felt that if indeed this theory is supported by any empirical evidence at all, it probably accounts for only a very low proportion of accidents without any statistical significance.

#### *The energy transfer theory*

Those who accept the energy transfer theory put forward the claim that a worker incurs injury or equipment suffers damage through a change of energy, and that for every change of energy there is a source, a path and a receiver. This theory is useful for determining injury causation and evaluating energy hazards and control methodology. Strategies can be developed which are either preventive, limiting or ameliorating with respect to the energy transfer. Control of energy transfer at the source can be achieved by the elimination of the source, changes made to the design or specification of elements of the work station, preventive maintenance. The path of energy transfer can be modified by enclosure of the path, installation of barriers, installation of absorbers, positioning of isolators. The receiver of energy transfer can be

assisted by limitation of exposure and use of personal protective equipment.

#### *The „symptoms versus causes“ theory*

The „symptoms versus causes“ theory is not so much a theory as an admonition to be heeded if accident causation is to be understood. Usually, when investigating accidents, we tend to fasten upon the obvious causes of the accident to the neglect of the root causes. Unsafe acts and unsafe conditions are the symptoms, the proximate causes, and not the root causes of the accident.

### **Structure of accidents**

The belief that accidents are caused and can be prevented makes it imperative for us to study those factors which are likely to favor the occurrence of accidents. By studying such factors, the root causes of accidents can be isolated and necessary steps can be taken to prevent the recurrence of the accidents. These root causes of accidents can be grouped as „immediate“ and „contributing“. The immediate causes are unsafe acts of the worker and unsafe conditions. The contributing causes could be management-related factors, the environment and the physical and mental condition of the worker. A combination of causes must converge in order to result in an accident (28, 29, 30, 31).

Human error is often cited as the cause of occupational mishaps and occupational accidents. The new view in ergonomics today does not see human errors as a cause, but as a symptom, as an effect of failure deeper inside the systems in which people work. Adherents of the new view use terms like system accident to attest to the multitude of factors, all necessary and only jointly sufficient to produce a failure and show the human contribution is only one of many (32).

The psychophysical state of workers can play a significant role in a developing of occupational accidents. The risk of being involved in an occupational accident was about two fold among heavy sharers and increased by 50% among men suffering from obstructive sleep apnea syndrome. Reduced vigilance and attention due to sleep disordered breathing are the proposed mechanisms behind the results (30). Hearing and visual impairments are risk factors for occupational injuries (31). Workers who reported more anxiety reported more injuries and took fewer safety precautions (15).

### **Cause of injury**

A distinction must be made between cause of accident and cause of injury. External cause categories for work related injuries are motor vehicle crashes cuts, falls, electrocutions, machine related incidents, being struck by falling objects, being hit by moving objects, caught in, under or between, contact with temperature extremes, contact with radiation, caustics, toxic and noxious substances (22, 33, 34).

### Prevention of occupational accidents

Prevention of occupational injuries is an important task for human resource management. Intervention to reduce occupational trauma should be multi-factorial to be successful. Activities on different levels, workplace visits, risk assessment activities, development projects targeting certain risks, print media and electronic media campaigns, attitude surveys among the general public need to be combined in order to influence claims incidence and underlying occupational morbidity. In depth analyses of the specific tasks and risk exposures identified together with a systematic collection of risk scenarios from exposed workers through critical incident and other techniques, should be the next step of intervention. Occupationally and task related appropriate engineering, ergonomics and design solutions should be developed for the different problems highlighted above. The choice of such applied development activities should be made with a priority towards reducing injury severity. Substantial reductions in non fatal injuries may reflect changes in work organization, increased automation and improved safety standards. Knowledge of predictors of work related injury, comprehensive training for workers may contribute to injury prevention strategies especially among newly employed workers (19).

Development of a standardized surveillance occupational injury database across companies with different database configuration is feasible (35). Personal protective equipments dramatically reduced injuries incidence severity and days lost to medical leave (36).

An effective safety program results from a multidisciplinary effort involving inputs from and interactions among many groups within an organization. To institute a successful program, it is necessary to establish a plant level safety committee with overall responsibility for administering the program. The screening committee should include upper level line managers (plant manager or designate and heads of production departments) and plant physician or nurse, the safety manager, plant level staff managers, and labor representatives. This committee should oversee the activities of departmental safety committees, which run the day to day safety program and solve problems on the plant floor. For the safety program to be effective, it is essential that the departmental committees be organized to encourage active participation by supervisors and hourly workers.

Upper level managers must establish a safety policy, develop the policy into a program, and ensure that the program is effectively executed. Although safety policies vary from one organization to another, most safety policies will include the following items:

1. A commitment to provide the greatest possible safety to all employees and ensure that all facilities and process will be designed with this objective. Similarly, purchasing policies must provide that all equipment, machines, and tools meet the highest safety standards.
2. A requirement that all occupational injuries and accidents be reported and corrective

action taken to ensure that similar incidents do not occur.

3. Clear explanation to all employees of the safety and health hazards to which they are exposed and the establishment of training program to inform employees of how to minimize their risk of being affected.
4. Regularly scheduled systems safety analyses of all process and work stations to identify potential safety hazards so that corrective actions can be taken before accidents occur.
5. Disciplinary procedures for employees who engage in unsafe behavior and for supervisors who encourage or permit unsafe activities.

While the chief executive officer is ultimately responsible for the safety of all employees, this responsibility should be delegated throughout all levels of management.

Line and floor supervisors play a key role in the execution of safety programs because of their direct contact with employees. Supervisors must ensure that all pieces of equipment comply with applicable safety standards and regulations and that employees use safe work practices. In addition, the supervisor must make certain that all injuries are promptly reported and treated. Some organizations use safety competitions, in which supervisors compete to achieve the best safety record. These contests yield beneficial results when supervisors are encouraged to bring their departments into compliance with applicable safety standards and regulations. Unfortunately, however, such competitions sometimes discourage the accurate reporting of accidents or appropriate medical care for injuries. For this reason, safety competitions may lead to unintended and counterproductive results and should be undertaken with caution. Care should also be taken to avoid giving supervisors incompatible goals, such as unreasonably high production standards, when lower rates are necessary to guarantee safety.

Larger worksites usually have a full time safety director, a manager responsible for the day to day administration of the safety program. Typical responsibilities include developing and presenting safety training, inspecting facilities and operations for unsafe conditions and practices, conducting accident investigations, maintaining accident records and performing analyses to identify causal factors, and developing programs for hazard control. The safety director must work with the engineering and purchasing departments to ensure that equipment and facilities are designed and purchased in compliance with all applicable safety standards. The safety director also works closely with the plants medical staff to ensure that all injuries are properly recorded and investigated. A full time safety director should be certified by the Board of Certified Safety Professionals. For smaller worksites that do not employ a full time safety director, the duties described above should be assigned to managerial personnel on a part-time basis or to a qualified safety consultant.

Regardless of the size and structure of the plants medical services, physicians and nurses play

an essential role in the plant safety program through primary treatment of injured workers and by helping to identify workplace hazards. While the causes of overt trauma injuries are usually obvious, causes of cumulative trauma are often subtle and difficult to identify. By evaluating patterns of employee injuries, disorders, and complaints, the physicians or nurse can provide early detection of potentially hazardous operations and process. Whenever disorders or complaints are suspected of being work related, this information should be reported to the plant safety director and responsible supervisor.

The physician and nurse should participate in the subsequent worksite investigations to identify specific hazards or stresses potentially causing the observed injuries and in planning the subsequent hazard control program. Finally, physicians and nurses must work closely and cooperatively with supervisors to ensure the prompt reporting and treatment of all work related health and safety problems.

The maintenance department and skilled trades play a critical role in the success of the safety program by routinely inspecting facilities, equipment, and tools, and servicing them when necessary. Individuals in these groups should receive special training to enhance their knowledge of safety hazards and control technology.

Finally, workers play an essential role in successful execution of a safety program. Prior to a new assignment, a worker must be educated regarding specific hazards associated with the new job. Training, should include both hazard recognition and control techniques. If personal protective equipment is required to ensure safety, training must cover how to inspect, maintain, and wear such equipment. Training must emphasize the responsibility of each worker to maintain a safe work station and to comply with safe work practices. Part of this responsibility includes reporting unsafe conditions to supervisors and employee safety representatives so that corrective action can be taken.

Employee participation is an important component of the total safety program. Each worker is an expert in his or her job and should be actively involved in inspections and systems safety analyses. If modifications are deemed necessary to reduce hazards, worker acceptance of new equipment, tools, and work methods is an essential ingredient in the successful implementation of change. Workers should actively participate in design of equipment and process safety features and selection of personal protective equipment.

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## PREVENCIJA POVREDA NA RADU

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Zdravstvena služba, doktori i medicinske sestre imaju značajnu ulogu u bezbednosti na radu, primarnom tretmanu povređenih radnika i u identifikaciji rizika na radnom mestu. Analizirajući uzroke povreda na radu doktori i medicinske sestre rade na ranom otkrivanju potencijalnih rizičnih operacija i tehnoloških procesa. Zdravstveni radnici mogu biti značajan deo tima koji radi na izradi programa prevencije povreda na radu. Nezgode na poslu, i njima izazvane povrede, i smrt imaju mnogobrojne uzroke i prisutne su kod velikog broja radnika različitih zanimanja i profesija. Mnogobrojni faktori i rizici doprinose povredama na radu. Najčešće su to profesionalne štetnosti, uslovi na radnom mestu, tehnološki proces rada, organizacioni, ekonomski i ostali socijalni faktori. Veliki je broj teorija koje pokušavaju da objasne nastajanje nezgode i povrede na radu, ali još uvek ne postoji jedinstveno tumačenje koje može da objasni nastajanje svake povrede i nezgode. Različite su mere prevencije i one zavise, pre svega, od radnog mesta. One podrazumevaju kontrolu radnih mesta od strane inženjera zaštite na radu, preventivne mere, tehnološka rešenja i ulaganja u menadžment, sigurnost, kontrolu rizika, edukaciju i trening. Istraživanja u ovoj oblasti i primena rezultata ovih istraživanja u praksi zahtevaju multidisciplinarni pristup. *Acta Medica Medianae* 2004; 43 (1):49 – 55.

**Ključne reči:** prevencija, nezgode na poslu, povreda na radu, profesionalne štetnosti, radnici, industrija