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Heavy Machinery, Amputations and Industrial Accidents

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Abstract

The article presents a description of heavy machineries, amputations and industrial accidents; an important component of occupational health. *Occupational Health* is the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations by preventing departures from *health*, controlling risks and the adaptation of work to people, and people to their jobs(WHO).

The Bureau of Labor Statistics reported a total of 4,836 work injuries in the United States in 2015, a slight increase from 4,821 fatal injuries reported in 2014. Since work-related injuries are not on the decline and work related hazards are a potential source of litigation, huge compensation, economic loss, and loss of quality of life it is important to explore the subject of industrial injuries and its attendant complications and how it can be prevented in an attempt to mitigate the potential cost on industrial workers, their families, employers, the production process and consequently the Gross Domestic Product of a nation.

The article attempts to describe etiologic and causative factors involved with the burden of heavy machinery and industrial injuries of which amputation is notable. A brief review of the agents of injury, mechanisms of injury, health and economic impact and the transmission pathway is included. A review of the literature would bring to the fore research materials that discussed the subject matter under review identifying pros and cons of various approaches. The article analyzes the available statistical measures provided by researches under review, revealing their shortcomings and highlighting their merits. The paper highlights potential future developments as relates to prevention and control of workplace injuries and their attendant complications. Additionally, certain recommendations will be made based on scientifically valid opinion.

Keywords: Industrial injuries, Amputations, Machinery, Occupational safety

1.1 Introduction

Amputation injuries often occur when an individual has to utilize machinery or heavy equipment to get their job done. [1] Amputations may happen when an individual is involved in an extreme workplace accident. Work-place accidents that involves automated or manual machines have become important because of the dire consequences and impact on workers' health and wellbeing.[1] Despite sound critical statements and in-depth explanations that bring errors of operators to the fore, amputations and industrial accidents remain predominant with industrial workers. This has put a strain on preventive measures that seek to improve product-system reliability.[1]

In the U.S., an average of 185,000 amputations occur on a yearly basis.[2] About 400 Americans lose a limb daily. One out of every 190 Americans alive has a prior history of limb loss, this statistic is projected to be twice what it is by 2050.[2] One of the leading causes of trauma-related amputations is industrial accidents. In a report by the Bureau of Labor Statistics (BLS), there was an average of 11,000 work-place amputations yearly over a 7year period. More than half of these occurred in the manufacturing sector. About 1,000 amputations occurred yearly in the retail and construction sector. Occupational amputation injuries related to equipment and machinery account for 60%, this is based on the BLS report. Mechanical power presses, hydraulic presses, and pneumatic presses are the most common cause of limb loss. In addition to this list is plastic processing machines such as thermo-forming.[2]

Furthermore, Occupational Safety & Health Administration (OSHA), has stated that certain industrial workers are more at risk of sustaining workplace injuries and accidentally amputated limbs than others. It was noticed that persons who work with machinery that possess blades and rotate can snag upon clothing's or different body parts. In addition, machinery that involves motions which are back and forth have the potential for entrapping different body parts but notably limbs. Slicing and punching equipment have also become prominent sources of hand related injuries. Equipment for stamping in the industrial arena have also been associated with limb amputations. Machineries with sharp edges are known for the tragic consequences of their use.[2]

Limb amputations occur during the regular operations of industrial machineries, but specifically during routine maintenance; machine start-up and machine wind-down operations. OSHA has stated that many of such industrial accidents resulting in amputations have settings where the employers do not have proper lock-out and start- up protocols to prevent such occurrences. As a consequence, machines could be accidentally turned on while another staff is cleaning or when maintenance procedures are ongoing on the machine. At other times employees are not formally trained about the proper procedures to be followed to prevent accidental workplace injuries. Many organizations are lacking in adequate workplace protective devices. Instances occur where such devices exist but workers become negligent on routine use of the protective devices. Poor maintenance of machinery by employers and failure to provide safety barrier all contribute to the burden of industrial accidents.[3]

The loss of an arm or leg; partial or total or any other appendages brings with it extreme physical and psychological problems that negatively affects the life of such individuals. Such psychological effects on victims could range from phantom pain which often persist many years after the accident has occurred. In addition to the psychological and emotional effects amputation has on its victims, the financial involvement on the road to recovery is extreme. In the Journal of Bone & Joint Surgery, a study published on this subject estimates $510,000 as the lifetime medical cost for a patient who suffers an amputation. The projected estimate by the study takes into cognizance, treatments cost that include: Initial treatment cost and hospitalization, follow-up cost and the cost for inpatient rehabilitation. In addition, the cost for outpatient doctor visits was factored in. Other factors accounting for the total cost were occupational and physical therapy as well as prostheses.[2]

The economic burden caused by industrial accidents are extreme for the following reasons: Pension payments for incapacity for work, cost of treatment, loss of production capabilities, distorted schedules of production, machinery damage and damage to other production equipment. Nevertheless, the asset of human life cannot be substituted for, neither can the pain suffered as a result of industrial accidents. Work accidents play an outrageous negative impact in national welfare and progress. Thereby decreases a country's capacity for productivity.[3]

As an OSHA requirement, employers are required to purchase only machinery that have adequate safeguards and protective measures installed to safeguard workers from amputations and other industrial accidents. Equipment's that are deficient in pre-existing safeguards would require safeguard installations by employers before they can be utilized in the industrial process. These safeguards are often in the form of barriers which are structured to act as a protective shield often through barricades created between the worker and the industrial machine. They usually are designed to minimize obstruction and visual interferences while the machines are running and the worker is carrying out his or her duty. Other safeguard measures notable for preventing accidental amputation are equipment's and machineries that will stop automatically when an industrial worker's hands or appendages are at the most vulnerable point for injury during operations. In addition, certain devices are designed to prevent the worker from placing his hands in hazardous areas in the equipment. These designs on devices can act to enhance the safety features of barricades and thereby help to reduce the incidence of occupational limb amputations.[1]

This article seeks to address; how many, who, how, where amputations and industrial accidents occur and its impact; all of which form a basic premise of prevention. If we do not have accurate information on its occurrence, we would have difficulty knowing how much resources to devote, what actions to take or whether the actions we do take are effective.

1.2 Background

There has been an expansion of various sectors of industrial production to keep up with increased demand due to rapid population growth, industrialization, urbanization and ever increasing standards of living seen in different parts of the world. Many unexpected and undesirable occupational incidents in relation to work safety that take place during industrial processes jeopardize workplace efficiency, productivity and cause serious financial losses to such organizations. Worse still, is the waste of labor and time which results as a consequence of industrial accidents, since workers may have to help the injured. Also, involvement of observing personnel and administrative staff in the industrial process when accidents do occur results in waste of labor and time, and consequently slows down the production process. When accidents occur, the mood and motivation levels of other workers is often negatively impacted and negatively affects the production process due to qualitative and quantitative decreases in production with dire financial repercussions. Furthermore, replacing an injured worker with a new worker often does require training in the desired skills and brings additional overall costs to the company.

Industrial accidents play an extremely negative role in national progress and welfare and is notably one of the factors that decreases productive capacities of nations.[4]

1.3 Current Research Efforts.

According to a study by Demiral et al, underreporting of occupational injuries is common in developing countries due to low official labor force participation, high unemployment rate and inadequacy of the Occupational Health and Safety Act. He further said that approximately one among three workers in urban areas and three of four in rural areas are not registered to the social security institutions. This is an important barrier to the reporting of occupational injuries. As such even if the worker is officially insured, many cases are not reported due to the economic concerns of the employer in terms of compensation and due to fear of job loss. [5]

A study done in South Africa by Hughes et al in 2005 showed that the construction industry is very accident prone with the commonest incidents been amputation of limbs due to mishandling of heavy equipment and those related to carnage and heavy lifting machinery. Furthermore, injuries were attributed to the lack of discipline, fatigue and distraction of the workers.[6] The study showed that 48% of workplace injuries were due to negligence and carelessness of laborers. 24% due to lack of personal protective equipment, 15% due to unskilled and uninformed labor and 13% due to lack of workplace supervision.[6]

An article on the importance of safety awareness among students studying engineering in the U.S showed that in comparison of workplace injuries, young workers had greater susceptibility to work-related injuries. This finding was attributed to risk-taking behavior in young adults due to hormonal effects, cognitive deficiencies, and psychological deficiencies. Young people were also noted to ignore minimum safety requirements in laboratories and machine shops.[7]

A recent study in Venezuela on work related accidents in the upper limbs, had results which revealed that the most frequent injuries were amputations (12%), involving fingers(12%) and hands(6%). Male workers were more affected (88%) in work related accidents. Hand and fingers were the anatomical region predominantly involved. [8]

In a study done in a manufacturing company in Turkey, occupational diseases and accident insurance covered only approximately 9.7million employees out of 23million.This was attributed to the deficiency of insurance schemes, since the schemes did not cover occupational health services and compensation. OHS services are accessible only for workplaces employing more than 50workers. These on-site occupational health services provided primary care and basic occupational health services for only 12-15% of all employees. Based on the study most of the accidents occurred in small scale work places in Turkey.

Another study on Turkish Hard Coal Enterprise revealed that thousands of people had been killed and tens of thousands injured in work accidents to date. Most of the injured had become disabled or suffered psychological problems. The biggest and most tragic of such accidents was the firedamp disaster in 1992. According to the analysis results, the number of accidents rose as a result of the disaster in comparison with previous years. The loss of working days increased as a consequence of the number of fatalities. Subsequently, the investment required for the continuation of production went up. Inefficiency occurred as the number of inputs taken into consideration increased.[4]

During the 12 months preceding the study by Elenge et al, 392 accidents occurred, affecting 72.2% of miners. Tools handling represented 51.5%, of the accidents' causes, followed by handling heavy loads (32.9%). Factors such as age, seniority or apprenticeship did not generate significant differences. Contusions were the most common injuries (50.2%), followed by wounds (44.4%). These injuries were located in upper limbs (50.5%) and in lower limbs (29.3%). 80.5% of miners were cared for by their colleagues and 50% of them could not work for more than 3 days. Physical sequelae were reported by 19% of the injured miners.[9]

In another study by Sadeghain et al. A total of 66 Electricity Distribution Company workers were determined to be suffering from injuries due to accidents. The accidents mostly occurred in the summer (33%). Most of the injured workers (16.7%) belonged to the age groups of 25 to 29 and 40 to 44; there were no accidents reported for workers who were less than 20. About 48% of the accident victims had to be hospitalized. Furthermore, 35% of the accident victims were treated in outpatient clinics, and 7.4% of the accident victims died.[10]

In a descriptive study of Occupational accidents and their causes among Electricity Distribution Company Workers during an Eight-year Period in Iran, results indicated that most of the accidents occurred in summer, and 51.3% were during shift work. Worker negligence (malpractice) was the cause of 75% of deaths.

Type of employment had a significant relationship with type of injuries ($p < 0.05$). Most injuries were electrical burns.[11]

1.4 Discussion

Hand injuries have been considered to be the number one most preventable occupational injury according to reports by the U.S Bureau for Labor Statistics.[5] While considering multiple finger injuries, the most important risk factor was found to be machines. Wood, assimilated machines and metal works were said to be incriminated in as much as half of the multiple finger injuries. Small sized and medium sized enterprises were most affected from this process as regards occupational health and safety.

In a study on industrial accidents occurring in small and medium sized furniture manufacturing in Turkey, the rate of occupational accidents with milling machines was 18.8% and half of them were severe injuries.[5] In this study, milling machines were among the most frequently reported machine causing multiple finger injuries. Milling machines are electrically powered devices with sharp cutters. OSHA recommends installing safeguards around the milling machines point of operation so workers are shielded from direct contact with the cutting blade. Presses were shown to be one of the important risk factor for severe hand injury. As in the previous study, Stan burry et al reported that presses were the most frequently reported machines causing hand injuries.[5]

Injuries of the hand have been reported by Sorrock et al , to have an enormous impact on hand function and quality of life. Hand injuries affected individuals in their productive ages and each injury, regardless of its magnitude were associated with a degree of disability which in turn limited performance of occupational and daily activities. The hand is the most frequent body part injured and its injuries often require treatment in hospital emergency rooms.[5]

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Tong and Ding in 2008 examined the inputs used for the safety measurements against work accidents in China, using the Chames, Cooper and Rhodes model of data envelopment analysis. As a result of the optimization performed they concluded that expended funds could be saved, the need for safety management and technical staff could be eliminated and working hours devoted to safety could be reduced.[4]

The relationship between work related fatalities and equipment in the mining sector was statistically analyzed by Kecojevic et al and reported that equipment related deaths rose from 37% to 88% between 1995 and 2005. The relationship between working experience and the number of workers killed in equipment related incidents was also examined and it was noted that workers with less than 5years of proper mining experience constituted 44% of all fatalities.[12]

The effects of mining methods on safety and productivity in the coal mining industry was studied by San et al who collected accident logs of coal mining companies with two different layout and by using statistical analysis they observed that mechanized layouts resulted in fewer accidents because safety and productivity were more developed within these layouts. They also noted that the highest accident rate in both methods was for middle aged workers.[4]

In 1993, TTK noticed a general increase in the efficiency scores which indicated that considerable efforts had been made to improve work safety and worker's health. By means of the Central Gas Monitoring Station, which was established to counteract the 1992 firedamp disaster in TTK, sudden gas increases were monitored and all mining engineers and attendants working underground had methane measuring devices and all underground workers had gas masks. Underground water dams were designed against the danger of colliery fires caused by pressure decreases in casts and stone dust was used to prevent fires from spreading. The new safety precautions and inspections ensured that there were no fatal methane and coal dust explosions but there were still seemingly unimportant accidents, such as loose rock falls, back injuries and other injuries caused during the use of equipment that negatively affected the company and its workers.[4]

The mining sector is said to have the highest incidence of work accidents when compared to other sectors. The waste of domestic resources which consequently causes loss of working days and labor force,

negatively affects a country's economy. What makes mining different from other industrial sectors is that the mining environment is particularly dangerous. The underground production methods increase risk factors in terms of industrial accidents and also because coal is extremely important in meeting up with persistently increasing demands for energy.[12]

In many parts of the world like Brazil, industrial accidents with machines tend to be justified by employers in a manner that overly emphasizes the technicalities of the system and puts undue blame on the industrial worker who falls victim of such circumstances. This practice in Brazil is now denounced as it indirectly inhibits prevention. The Ministry of Labor and Employment (MTE) came up with a project which focuses on the prevention of industrial accidents by developing a Model of Analysis and Prevention of Accidents (MAPA).

An accident case which occurred with a worker who was in charge of operating a brake-clutch type mechanical press resulting in amputation of the worker's arm. The report by MTE revealed that the accident had occurred because one of the operators had activated the command to lower the hammer when the second industrial worker was still in the interior of the machine. Regardless of the barriers that should impede the closing of the operational zone, they emphasized the behavior of this worker, exploring the cognitive aspects of the incidence. They also assessed the existence of traps in the operation of the machine.[13] Further evaluation of the incidence by the MTE revealed that the safety devices in the said machine gave an illusion of safety. As a result, the machine was activated when a worker was still within the machines operational system.

This report by the MTE in Brazil brought to the fore the need for the following: preventive interventions to be tailored to workers individual characteristics, reducing the creation of traps and boosting industrial safety practices and policies that substitute judgement of behaviors that are involved in industrial accidents by analyzing the reasons that led the workers to act in a particular manner that exposed them to industrial acccidents.[13]

A study on how industrial accidents affected the general efficiency of production in Turkish Hard Coal Enterprise (TTK) between 1987 and 2006 revealed the sources of technical inefficiencies over the duration specified. The results showed that 69.7% was the overall technical efficiency, considered as very low. This was not unassociated with the disaster in 1992. It was concluded that industrial accidents had a negative effect on the efficiency of production. It was noticed based on the study that the greatest degree of technical inefficiency was when the highest number of work accidents were noticed as well.[4]

The riskiest mechanism for all types of injuries involves working with machines. However, the proportion of injuries which were hand related were noticed to be decreasing over time to a significant degree in a study in Turkey. This decrease was attributed to an increase in general preventive measures by manufacturers of machineries. This may also be due to an increase awareness of local preventive measure by employers such as the provision of personal protective equipment or protective devices added to machines. Within the European Union directives in 2001 and 2009 there was an improvement in machinery safety regulations in Turkey which highly lays emphasis on safety obligations and need for the implementation of improved safety measures to machines.[5]

A study done by Hart et al in 2004 revealed that a number of training programs on safety use of machines were inefficient and that ensuring effective protection by training may be more difficult to achieve than is adding a protective part to a machine. The study further revealed that in many cases, personal protective equipment like gloves do not change injury severity but only the type of injury. He was of the opinion that changing the design of machines in order to control the hazard from the source may be more of an important control measure. However, the study by Sherrard et al had a contrary opinion as the benefits of gloves as personal protective equipment were obvious. The study revealed for instance that wearing a steel glove on the left hand when using wood cutters or planning machines would protect workers from amputation.[5]

In a study that attempted to explain the correlation between the safety climate and the safety behaviors of employees of a ship yard operated by Turkish Navy, factors such as "safety and personal protective equipment use training", "absence of work pressures", "maintenance & spares" influenced safety behaviors positively. On the other hand, "communication"

factor had a negative influence upon the safety behavior. This finding might be the result of negative perception about communication factor. Inefficient communication practices or lack of effective communication systems might be responsible for the employee's dissatisfaction and negative perceptions.[14]

1.5 Recommendations

As far as loss prevention is concerned, every machine fails and people make mistakes. To prevent human or mechanical errors, the reliability of a system needs to be assured. However, the emergency response system of the last line of protection in a plant for instance, should be activated once personnel and safety protection devices fail. The accident should be eliminated or restrained effectively in the beginning so that damage can be limited.[15]

Standard protocols regarding industrial accidents must be in place to ensure prompt reporting of cases, a medical examination and assessment of severity and the need for compensation. Clinical data compiled from hospitals who give specialized care have become more informative than official statistics for initiating and implementing safety measures for occupational hand injuries. This reliance on clinical data is due to under-reporting of industrial accidents and should be maximally utilized particularly in the 3rd world where litigation is at its minimum, hence, employers are not held accountable for workplace related injuries. In designing safeguards for machinery, the informal sector should not be disregarded, as old technology must also be considered useful; giving additional precautions since many countries of the world still utilize old technology.

The use of protective equipment must be enforced with a stricter and more frequent supervision, possibly with punitive measures when industrial workers fail to comply. Prohibition by Law of the purchase of machinery by employers that do not provide or guarantee adequate protection of the industrial workers should also be enforced. There is also a need for training and recertification of safety engineers in all industries.

Employers and employees need to be better able to assess the risks of industrial accidents ex ante and allocate risks in an efficient way by incorporating risk premiums in wages. In this case the employer's incentive to prevent industrial accidents and compensate victims when they do occur would be embodied in the wage premium.[16]

1.6 Future Research

Research and concerted efforts on ways to improve the quality and completeness of occupational injury surveillance systems, particularly in developing countries is needed, as surveillance is the foundation of the public health framework as it allows us to establish baseline measures of the magnitude and risks of public health problems. [17]

Persistent problems that continue to kill industrial workers despite knowledge on how to prevent them requires that we expand our research to better understand and address the intractability of some injuries in the face of proven prevention measure, and when feasible, more fully utilize engineering approaches to mitigate injury hazards.[17]

Research institutions and researchers need to embrace engaging stakeholders throughout the research continuum to ensure that research is relevant to stakeholders to improve worker safety. Furthermore, there is need to capitalize on new technologies to enhance occupational injury research, as advances in information technology open up new opportunities for research, and it is incumbent that research is adapted to address changes in work and workers in a bid to enhance worker safety.[17]

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