THE DEVELOPMENT OF INTERACTIVE SOFTWARE FOR ASSESSING RISKS AND ESTIMATING INDUSTRIAL MAN-HOUR LOSS

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ABSTRACT

In lower income countries such as those of the South Asia and Africa, several workers are either ignorant or un-care about the risks associated with the jobs they do. This has led to frequent accident situations in industries causing colossal loss of resource. This paper presents the development of interactive software employed for assessing risks and estimating industrial man-hour loss and its economic implications. Accident investigation registers were administered to 21 various manufacturing and oil and gas industries to assess their workplace associated risks. Typical incident cases such as amputation, electrocution, asphyxia, crushes, head injuries, sprain, slips and falls, and some others were identified during the study duration. It was discovered that about 24 hours to 3,158 hours could be lost depending on the severity of injuries/accidents. For catastrophic category of injuries/accidents, a worker could be render incapable or even dies. A mathematical relation was formulated for quantifying the man-hour losses in monetary values.

Keywords: *Man-hour loss, Accident investigation register, Risks, Accidents, Estimation*

1. INTRODUCTION

Despite enormous advances in technology, human factors engineering (ergonomics), preventive medicine and other means to prevent accidents, an estimated 120 million occupational injuries occur annually at workplaces worldwide [1,2,3,4,5] (Adebiyi and Ajimotokan, 2010; Ajimotokan, 2009; Apurna *et al*, 2004; ILO, 2002; Saari, 1998). Apart from the cost due to downtime, overtime work, loss of machine-hours, man-hours, wages and equipment and hospitalization, the tragedy associated with personal injury, disability and fatality is enormous. In respect of fatalities, industrial accidents take the third place after vehicular accidents and homicide [6] (Adebiyi and Charles-Owaba, 2009). In lower income countries such as those of the South Asia and Africa, injuries are one of the leading causes of adult mortality and a major contributor to disability [7,8,9,10,11]. Death, illness and injury on such a scale impoverish individuals and their families, and challenge attempts to improve working conditions [4]. When any of these occurs, there is need for safety evaluation and management to enhance safety performance and consciousness.
However, in Nigerian industries, especially the small and medium scale enterprises, the subject of safety are considered optional [12] and so many workers are either ignorant or unconcerned about the risks associated with the work they do. This paper presents the development of a users' friendly interactive software in Visual Basic programming for assessing risks and estimating man-hour loss as a result of injuries/accidents.

2. METHODOLOGY

In carrying out this research work, 21 industries in Nigeria were visited: four manufacturing, four oil and gas, five food and drinks, three cement and five flour mill industries. The associated risks of each company was analyzed and recorded. These were employed to develop the database for the Visual Basic computer programme.

2.1 Man-Hours Lost

Data registers were employed to capture the needed data from University of Ilorin Teaching Hospital, Civil Service Clinic and the private clinics in Ilorin, Kwara State. The data registers were reviewed and analyzed to ascertain the number of days or weeks a worker was away from work as a result of injuries /accidents. The results obtained are depicted in Table1.

For Catastrophic cases of injuries/accidents, some of the responses are indefinite period of days away from work, which means a worker could be rendered totally incapable or even die, as a result of catastrophic cases of injuries/accidents.

Table 1: Man-Hours Lost due to Injuries/Accidents (in Hours)

Injury/Accident	Minor	Major	Hazardous	Catastrophic
Bruises, cut, laceration	72	240	448	1176
Burn	264	420	644	1109
Chemical or hot metal burn	302	470	784	1554
Crushing or shearing	240	504	756	2592
Electrical Shock	96	315	476	840
Eye injury/Blindness	168	364	538	924
Face/body damage	216	336	706	672
Fire	192	504	756	2352
Fracture	240	1008	1792	3158
Head Injury	168	462	798	3080
Hearing damage/Deafness	216	437	720	560
Radiation Exposure	168	370	672	2268
Slip/Fall	72	364	1064	2318
Sprain	72	264	364	605
Strain	72	294	384	538
Suffocation	72	192	336	538

Note: Minor: Not severe injury; **Major**: Severe injury; **Hazardous**: Very severe injury; **Catastrophic**: Life threatening injury

3. LOSS ESTIMATION AND PROBABILITY

3.1 Estimation of Losses

The following relations were formulated to estimate the financial loss implication due to injuries/accidents sustained by workers. The man-hour financial loss, δ, is given by:

$$\delta = n_{i,k}\, H_{i,k}\, R_j \tag{1}$$

where i = accident type, j = particular ranking, k = accident severity categories (minor, major, hazardous, and catastrophic), n = number of occurrence, H = number of hour loss due to a particular injury/accident, R = hourly rating for a particular ranking (grade level), which is a constant value for the worker concerned.

R = (Total annual salary of a given ranking) / (365*24) (2)

Note: The value of H differs from one country to another depending on the sophistication of the medical equipment and the expertise of the medical practitioners.

The total financial loss as a result of injuries/accidents sustained by a worker is given by:

$$\delta_p = \sum_p n_{i,k} H_{i,k} R_j \tag{3}$$

where p = total number of injuries/accidents experience by a particular worker.

The total financial loss as a result of injuries/accidents sustained by all workers in the organization is given by:

$$\delta_W = \sum \left(\sum_p n_{i,k} H_{i,k} R_j \right) \tag{4}$$

where w = all workers

The gross total financial implication to the organization is given as,

$$\delta gt = \sum \left(\sum_p n_{i,k} H_{i,k} R_j \right) + mb \tag{5}$$

where mb is the medical bill

3.2 Probability Report

The Poisson distribution was used to generate the probability output in the Visual Basic Program for risk assessment. The Poisson distribution is given as:

$$P(Z) = \frac{e^{-\lambda} \lambda^Z}{Z!} \tag{6}$$

when 0 ≤ P ≤ 1, λ > 0

The variance of the distribution of the data collected is,

$$S^2 = \frac{\left(X - \overline{X}\right)^2}{N-1} \quad (7)$$

The standard deviation of the data distribution is,

$$S = \sqrt{\frac{\left(X - \overline{X}\right)^2}{N-1}} \quad (8)$$

where Z = number of occurrence, λ= mean or average number of occurrence, e = exponential function, X = data value, $\overline{X}$ = mean value of set data, N = number of data value

4. PROGRAMME DESIGN AND IMPLEMENTATION

4.1 Overview

In accordance with the objective of the project, an application was developed to perform risk assessment for any work environment. It can be used to compute the probability of particular incidents occurring and also to estimate the financial loss due to injuries/accidents by organization. The application requires the user to register accident types, which are going to be handled by it. The application requires the user to enter records of risk conditions, which are likely to lead to the registered accident types, as well as records of every accident, which takes place. All these information are used by the application to perform risk assessment as well as compute the probability of the accidents occurring.

A risk record condition consists of the following data items: the hazardous condition, incident likely to occur due to the hazardous condition and a control measure for the hazardous condition.

An accident record consists of the following data items: the date of occurrence of the accident, the accident type, the severity level of the accident, the number of injured persons, the number of fatalities and causes of accident (if any)

All records entered using the application were stored in a database. The application is also capable of generating reports and charts of accidents according to type, severity, or casualties.

4.2 User Interface Design

The application has a user interface made up of 8 windows.

Main window: This window is always the first window of the application to be displayed. It is displayed whenever the application is started.

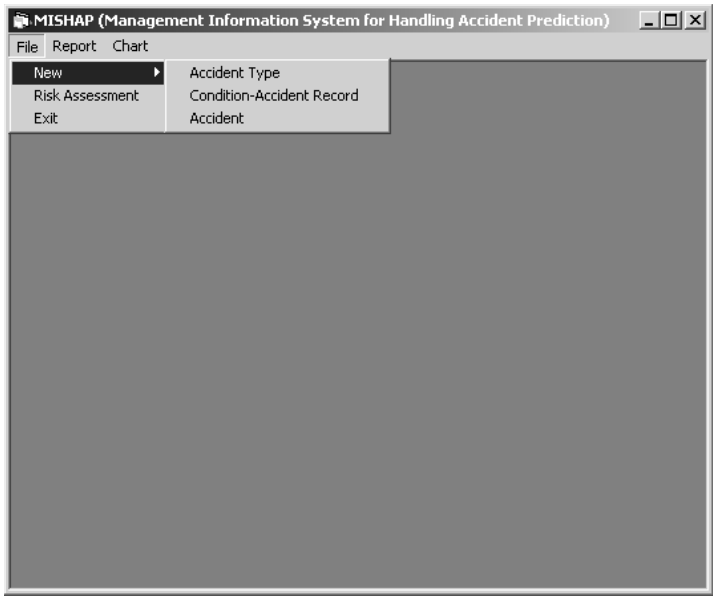

Figure 1: Main Window

All other windows of the application are displayed directly or indirectly from it. By extension, all functions of the programme are accessed directly or indirectly from it. It can be considered to be the control center or control panel of the application. It has a menu bar, and the menu system of the window is given in the following illustration.

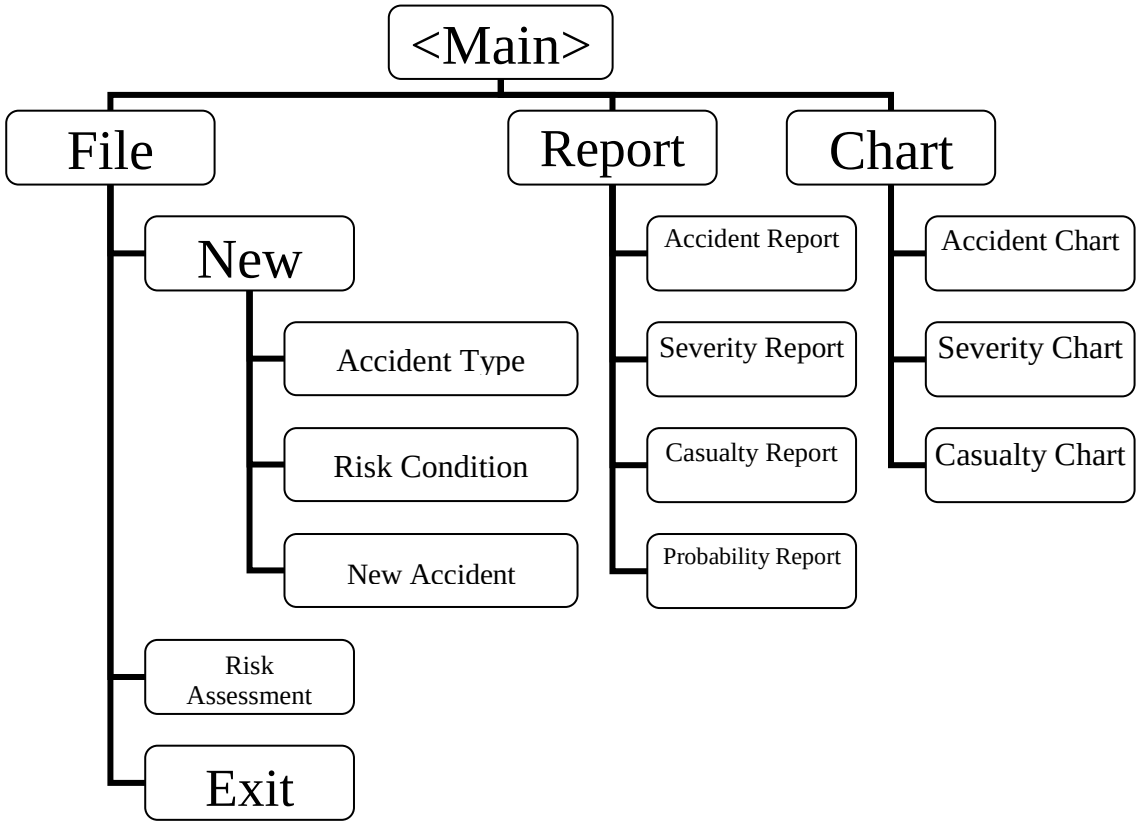

Figure 2: Menu Structure of the Main Window

New Accident Type dialog box: This window is for storing records of the accident types on the computer.
New Risk Condition dialog box: This window is for storing records of risk conditions likely to cause known accident types.
New Accident dialog box: This is a window for storing records of accidents on the computer.
Select Incident dialog box. This window is for selecting a particular incident, for which risk assessment is to be done.
Risk Assessment Wizard dialog box: This window is for displaying questions during risk assessment, and for obtaining user responses.
Select Month dialog box: This window is for selecting a month for which a chart is to be generated.
Output Window: This window is used basically for displaying programme output. It is a child window to the main window of the application.

5. RESULTS AND DISCUSSION

The application has several functions: it can perform risk assessment and statistical safety analysis. It also allows the entering of new data to suit the user's purpose. The estimation of man-hour financial losses on a particular category of injury/accident can be done employing the formulated man-hour lost parameters and total financial loss due to injuries/accidents is also obtainable employing the programme. A typical chart generated by the programme is shown in Figure 3 while Figure 4 shows the man-hour lost for each severity case; namely: minor, major, hazardous, and catastrophic; and the relationship between all injuries/accidents categories. This graph shows that the more severe an injury/accident is the more lost man-hour by the organization. Also, it is noticed from the figure that there is an unusual sharp rise in man-hour loss for cases like amputation, fracture, crushing/shearing, burn and slip/fall.

This means organizations must take extra effort to prevent and control these injuries/accidents. The lost man-hour for catastrophic cases was too enormous that sometimes they cannot be quantified because a worker could be rendered incapable or even dies. The socioeconomic implication is that a lot of money, in forms of days a worker is away from work and treatment bill, is lost or rendered incapable due to the injury/accident.

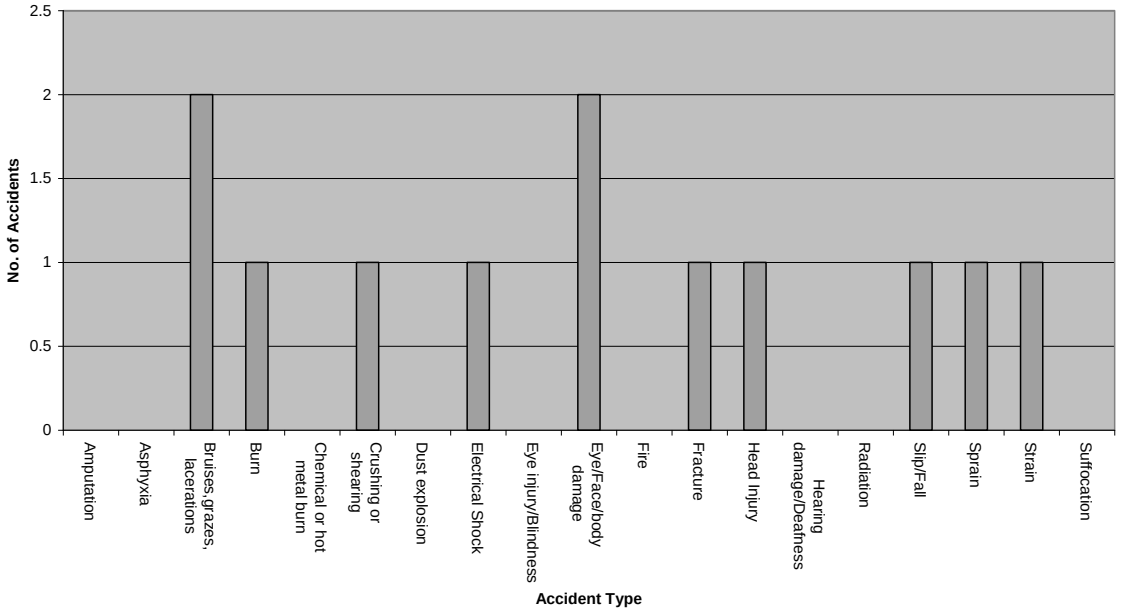

Figure 3: A Typical Chart Output

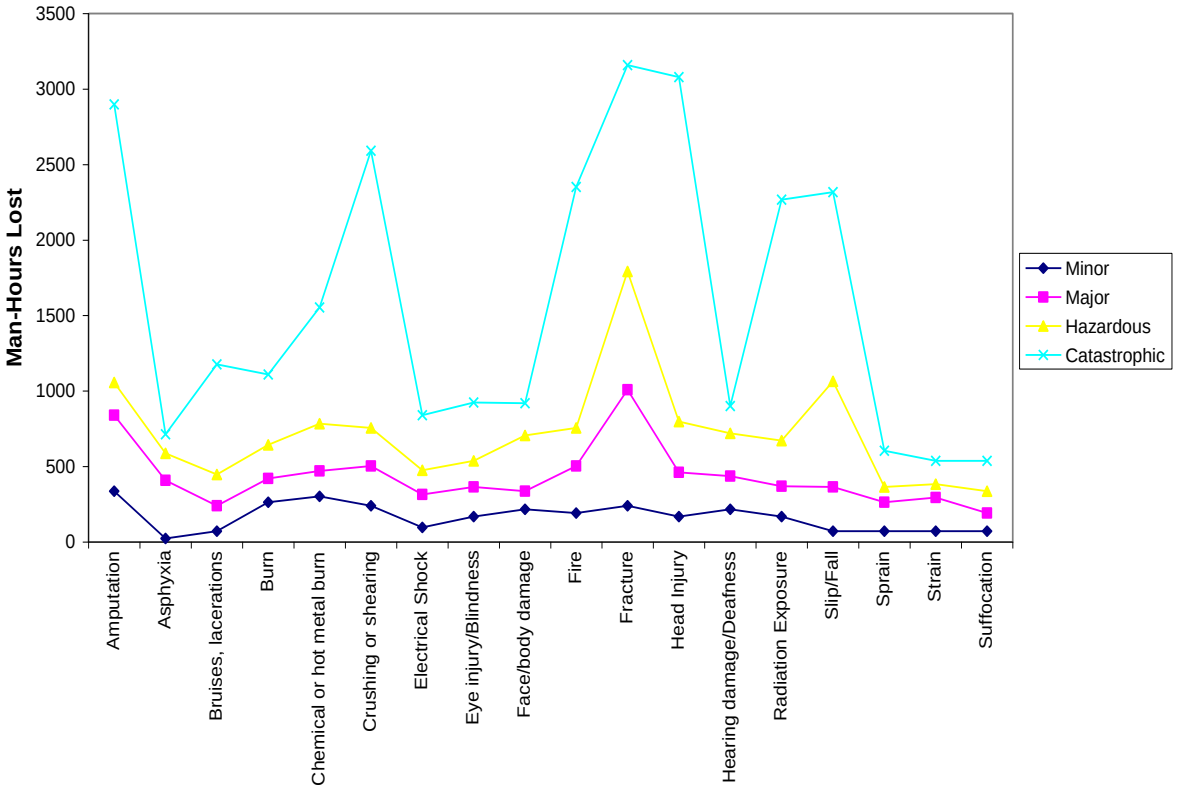

Figure 4: Comparison of all categories of Injuries/Accidents

6. CONCLUSIONS

Visual Basic 6.0 has been found suitable as an application programme for the development of software for estimating man-hour loss, as well as for quantifying the financial loss incurred by an organization due to injuries/accidents that occur in workplaces. The developed software package has also been found to be of adequate flexibility, user friendly and very interactive. Safety engineers and of course all workers can find this software as a workable tool for risk assessments. This software will also be of so much help to the decision makers in industries for safe work place planning and evaluation.

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