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Development of Neurobehavioral Deterioration Risk Prediction Model for Welder: A Proposed Study

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Abstract: Risk prediction model estimate the risk of emerging upcoming outcomes for individual based on several underlying characteristics. In welding process, welders have the high risk to expose with the toxicant element which can harm the neuropsychological of a welder. This proposed study will develop a prediction model on neurobehavioral deterioration risk of welders. In order to get the intensity of heavy metal exposure of the welders, airborne personal monitoring and toenail biomarker test will be carried out. Meanwhile, for the neurotoxicity assessment, the workers will undergo the neurobehavioral core test battery and questionnaire survey to identify the neurobehavioral score level. Detail statistical analysis between both assessment results will be carried out for development of prediction model based on artificial neural network. After validation test, the developed artificial neural network prediction model will be applied to another metal base industry for verification purpose. Length of abstract can be proportional to the length of the article. Through this study, it is expected neurobehavioral risk prediction model on detection on early symptoms of neurobehavioral deterioration will be developed This study contribute to better understanding on the effects of heavy metals exposure, especially to central nervous systems among welders.

Keywords: Artificial Neural Network, Biomarker, Neurobehavioral, Prediction Model, Welding Fume Exposure.

1. Introduction

The United State Department of Labour reports that over than 300,000 all day specialists in the United States are engaged with welding processes. This figure surpasses more than two million workers all inclusive. Welders are a heterogeneous working populace, utilized in various settings that incorporate open, well-ventilated spaces (e.g., outdoor construction sites) or confined and ineffectively ventilated spaces (e.g., ship hulls, building crawl spaces, and pipelines) [1].

As per the Malaysia Ministry of International Trade and Industry (MITI), the steel demand and imports for ASEAN nations are strongly expending since 2010. Figure 1 illustrates the augmentation demand and production of steel starting from the year 2002 till 2014 onward. This is because of the expending of technology and a world economy that required the assembling business to boost their production of steel to meet the demand and necessity. As a major of the ASEAN nations, Malaysia likewise involved direct and by implication with the steel foundry and assembling business. Hence the workers engaged with welding procedures will likewise increment by years in Malaysia [2].

Welders are unprotected to heavy metals including manganese (Mn), lead (Pb), nickel (Ni), cadmium (Cd), and arsenic (As) when liquefied metal from steel, electrodes, or wires is overlooked. Trifling round particles (50–300 nm in width) contained in volatilized welding smoke can accomplish profound into the alveolar region of the lung and pledge wellbeing impacts. In addition, toxicological investigations propose that these little particles may sidestep the blood-cognitive hindrance by experiencing the olfactory nerves to cerebrum territories, introducing a course of focal sensory coordination impacts. Transitional and longstanding weld smoke exposures have been appeared to deliver cardiac diseases, pulmonary, and neurological effects [3]. These exposures can lead to the neurotoxic symptoms, which normally ignored by the workers.

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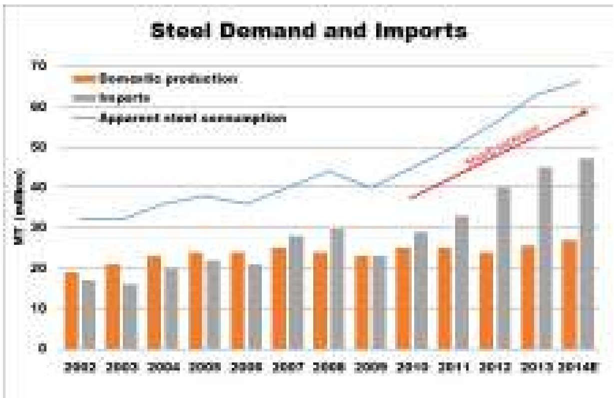


Fig. 1: The Steel Demand and Import statistic [2].

One of the principles of wellbeing and clinical research is to distinguish people who have a high jeopardy of developing an adversative result over a definite day and age so that they can be beleaguered for early counteractive action stratagems and conceivable management. A hazard prediction model needs to be industrialized for work-related wellbeing forecast due to inadequate in amount for neurobehavioral studies.

Therefore, there is an imperative need to discover the likelihood of evolving hazard forecast algorithm for the work-related wellbeing issue. Among the published studies, the examination about the relationship of welding smoke contact and neurobehavioral execution is as yet restricted in Malaysia populace. Consequently, this investigation aims to improve and proposed a neurobehavioral worsening forecast algorithm for welders in view of inclusive real figures assemblage, examination, and verification with real contextual investigations.

2. Materials and Methods

This study will focus on the welder populace with a cross-sectional approach. The indoor environment welding work will be chosen rather than outdoor because of wild parameters to be reflected and may delude the result acquired. The certain workers in this investigation in view of the day-to-day equivalent work task for no less than eight hours for each day. The inhalable hazard considered in this study are only fumes and dust instead of radiation, noise, and vibration hazards. This study only considered the inhalable course of exposure even the possible exposure course of heavy metal into the body include the diet (food and water), dermal and injection. The blue collar worker will be assigned as the exposed sample who exposed to welding fume pollutants while the white collar worker will be the case-control sample of this cross-sectional design of monitoring. The ratio for exposed and control sample are 2:1 respectively [4].

Figure 2 show the whole proses of neurobehavioral deterioration risk prediction model development starting from Phase 1 where the questionnaire development and verification process. While in Phase 2, the data collection and in Phase 3 the risk prediction model development and verification process.

In term to get the intensity of heavy metal exposure of the welders, airborne personal monitoring and toenail biomarker test will be carried out. In the meantime, for the neurotoxicity assessment, the workers will undergo the neurobehavioral core test battery and questionnaire survey to identify the neurobehavioral score level. Detail statistical analysis between both assessment results will be carried out for development of prediction model based on the artificial neural network. After the validation test, the developed artificial neural network prediction model will be applied to another metal base industry for verification purpose.

Hazard forecast algorithms practice prognosticators (covariates) for assessment the outright likelihood or hazard that a definite result is available (analytic forecast algorithm) or drive for come to pass within a particular day and age (prognostic forecast algorithm) in a person with a specific prognosticator silhouette. An algorithm alludes to the (scientific) work which relates the existence or event of the result important to an arrangement of prognosticators [5].

2.1 Phase 1: Development of Neurobehavioral Risk Assessment Questionnaire

The development process of neurobehavioral risk assessment questionnaire will commence in two stages; the identification of variables involves and clarification the methodology evaluation systems. The aim in the identification of variable is to find the risk factors involves in neurobehavioral effects. While for the clarification of evaluation method is to identify types of scoring for neurobehavioral test and questionnaire analysis. These two stages can contribute to developing the artificial neural network based prediction model later. Then, a pilot test will be done to evaluate the validity and reliability of the developed questionnaire and designed research framework [3].

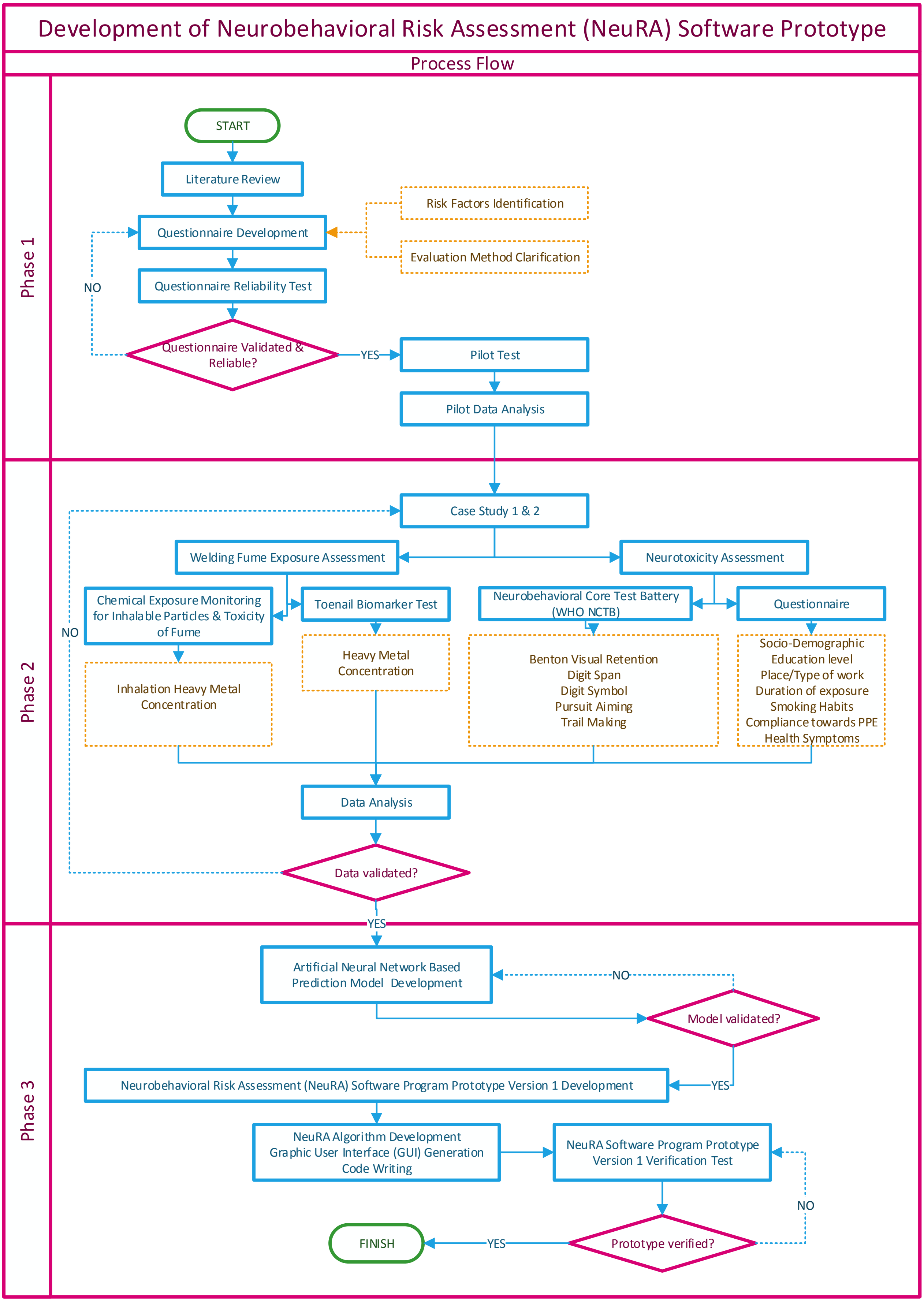


Fig. 2: Research framework and development process of Neurobehavioral Risk Assessment system.

Before the assessment begun, some basic relevant information need to be gathered as per recommended by Department of Safety and Health Malaysia in the Manual of Recommended Practice on Assessment of The Health Risk Arising from The Use of Chemicals Hazardous to Health at The Workplace [6]. The information which may include:

- Information on chemicals hazardous to health used or released in the workplace;
- Layout plan of work area;
- Process flowchart;
- Particulars on workers at risk;
- Control equipment design parameter and maintenance record;
- Occupational accident, dangerous occurrence, incidence, poisoning and disease record as well as corrective and preventive action records;
- Personal exposure monitoring program;
- Health and medical surveillance programme;
- Training programme related with use of chemicals hazardous to health (at the minimum, chemical hazard communication and emergency response);
- PPE programme;
- Standard operating procedures; and
- Safe work procedures.

2.2 Phase 2: Data Collection

In this phase, the data needed will be collected by two types of assessment which are welding fume exposure and neurotoxicity assessment. The data collection will be held at several case studies on automotive industries. Table 1 summarises the types of instruments used, the method that will be used, the duration of sampling and the number of samples needed for each area and personal sampling as proposed by Hariri et al., [7].

Table 1: Suggested sampling technique designed for sampling [7]

Scope	Work description
Sampling Type	Personal sampling: To identify the concentration of metal contaminants possibly inhaled by workers.
Instruments	Personal sampler set (personal sampling pump, filter holder and cassette, filter media and connecting tube). Unit: mg/m^3
Sampling Duration	Based on workplace condition and maximum volume to be sampled. - Full period (8 hours) single sample or, - Full sample (8 hours) consecutive sample [10-12].
Sampling Method	The sampling head located within the breathing zone (0.3 m in radius) extending in front of worker face, centre of midpoint of a line joining the ears; the base of the hemisphere is a plane through this line' the top of head and the larynx [13].
Number of sample	If maximum risk worker cannot be selected with reasonable certainty, it is necessary resort random sampling with similar expected worker exposure risk (partial sample for 10% and confident 0.90) [12]. At least one out of ten worker in a properly selected homogenous group performing similar task [14].

In order to collect the heavy metal accumulation on workers, chemical exposure monitoring for inhalable particles and toxicity of fume need to be performed by positioning the assessment equipment at static focuses zone in the area contaminant sources due to assess the emission of contaminant or in other words, area sampling. To assess the contaminant exposures, the personal sampling instrument will be connected to workers with the examining head inside the breathing area.

The detection of the concentration of heavy metal in worker's body will be assessed through the toenail biomarker test. According to Hariri et. al., the mean personal sampling heavy metal concentration and toenail accumulation concentration shows a significant relatable. Hence, the toenail accumulation was a reliable biomarker for continuous heavy metal exposure among welders [8]. A biomarker of acquaintance is any quantifiable natural parameter that shows ranks of acquaintance to a given lethal element, regardless whether it is a prompted protein, enzyme, metabolite, or the lethal substance itself [9].

The workers will be required to place the adequate toenail clipped of all 10 toenails into a small envelope or sample bag for analyses. Lead (Pb), manganese (Mn), cadmium (Cd), nickel (Ni), and arsenic (As) will be then analysed for concentrations of toenail samples at the indorsed lab via a dynamic response cell inductively coupled plasma mass spectrometer. Quality control measures will be performed in the laboratory include analysis of initial calibration verification standards, continuous calibration standards, procedural blanks, duplicate samples, spiked samples, quality control standards, and certified reference material [2] .

Toenail clippings from all ten toes will be combined for each sample and analysed as previously described. Briefly, prior to ICP-MS, external contaminants will be removed by sonication using a 1% Triton X-100 solution for 20 minutes. Toenails will then rinsed repeatedly in Milli-Q water, dried, weighed, and digested in nitric acid. Each subject sample will undergo five replicate analyses. The net averaged concentration for each metal will be calculated by subtracting detectable laboratory blank concentrations within each batch [3].

For neurotoxicity assessment, it will involve two types of test which are Neurobehavioral Core Test Battery (NCTB) and questionnaire. NCTB is the battery test that was approved by the World Health Organization (WHO) functioning to provide a series or battery of neurobehavioral tests that was optimized to detect neurotoxicity in human populations who were non-mainstream [15].

The description of neurobehavioral test and function for each test is shown in Table 2. Meanwhile, the questionnaire being part of the test to investigate the socio-demographic criteria, education level, working history, duration of exposure, smoking habits, compliance towards PPE, health symptoms and lifestyle [16].

Table 2: Description of neurobehavioral test and functions in the test battery [16].

BARS Test	Cognitive Domains Function and Description
Digit Span	Test of attention and auditory memory in which a series of numbers between 1 and 9 are read to a participant who must, after the series is completed, repeat the series in order orally the numbers. The test is then repeated with new numbers, but participants are to repeat them backwards (that is, reverse of the order in which they were read).
Trail Making	The test can provide information about visual search speed, scanning, speed of processing, mental flexibility, as well as executive functioning
Reaction and Movement Time	Test of response speed presents a visual or auditory stimulus to which the participant is to respond as quickly as possible on a button indicating detection, producing a "reaction time".
Continuous performance	Measures sustained attention. Symbols are presented in an unpredictable order, and the participant has to press a button quickly at the appearance of a pre-selected symbol or when two symbols appear consecutively.
Symbol-Digit	Measuring perceptual organization, motor dexterity, and attention and speed performance. The digit symbol test worksheet contains a list of numbers that are associated with certain simple symbols and a list of random digits from one through nine with blank squares below each digit. The subject is required to fill the blank squares with the symbols paired to their corresponding digits and to do so as quickly as possible for 90 s.
Pursuit Aiming	The pursuit aiming test requires the subject use a pencil to place one dot inside each circle following the pattern given on the printed pursuit aiming test sheet. This task is to be performed as quickly as possible for 60 s.
Benton Visual Retention	The Benton visual retention test consists of 20 cards presented as 10 pairs of two. The first of each pair contains the pattern to be memorized, and the second contains four patterns, one of which is identical to the pattern presented previously. After looking at each card presented for 10s, the subject must recognize the right patterns among the confounders in the next card presented immediately thereafter.
Santa Ana Manual Dexterity	Timed perceptual – motor coordination for right and left hand. A plastic base plate with pegs fitted in rows of 12 was used. Each peg was to be removed, turned 180 degrees and replaced in its slot. The objective is to turn as many pegs as possible in 30 s. The test is repeated twice with the dominant hand and twice with the non-dominant hand. The number of pegs successfully turned is recorded as the test score.

2.3 Phase 3: ANN Deterioration Prediction Model Development

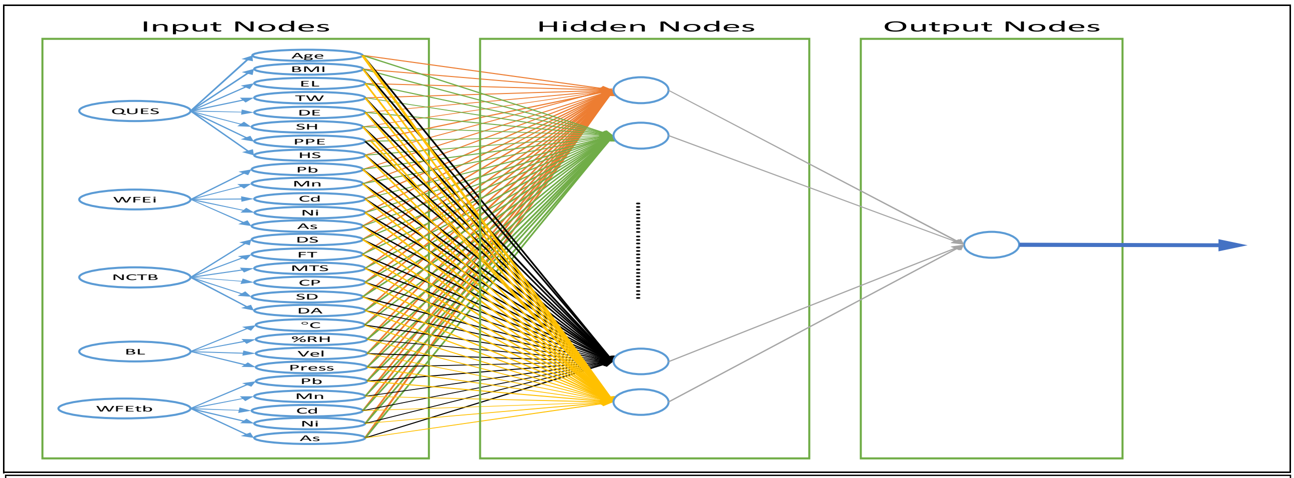
From the data collected, an artificial neural network based deterioration prediction model will be developed. After that, the model will be validated via the validation set data from the actual data. The artificial neural network will be used to develop the deterioration prediction model of neurobehavioral performance based on results obtained from the welding fume exposure and neurotoxicity assessment respectively by using the MATLAB neural network toolbox [17].

The ANN algorithm that will be used in this study is a standard feedforward, back-propagation neural network with three interconnected neurons which are positioning in at least three layers; input layer of source neurons, at least a hidden layer and an output layer of computational neurons as per Figure 3 [18].

The process of defining an appropriate neural network architecture can be divided into the following categories:

- Determining the type of neural network
- Determining the number of hidden neurons
- Selecting the type of transfer function
- Devising a training algorithm

Checking for over and/or underfitting of the results and validation of neural network output. In input layers, there are several input representations for each node that obtained from the questionnaires, welding fume concentration from personal sampling and toenail biomarker test, workplace background level and the



Abbreviation for Fig.3: QUEST: Questionnaire, TEi: Toxicant Exposure through inhalation, BARS: behaviour assessment and research system score, TEtb: Toxicant exposure accumulate in toenail biomarker, BMI: Body Mass Index, EL: Education level, TW: Types of weld, DE: Duration of exposure, SH: Smoking habits, PPE: compliance with PPE, HS: Health status, Pb: Lead, Mn: Manganese, Cd: Cadmium, As: Arsenic, DS: Digit Span, FT: Forward test, MTS: Movement test speed, CP: Continuous performance, SD: Symbols Digit, DA: Dexterity Ana, °C: Temperature, RH: Relative humidity, Vel: Velocity, Press: Pressure

Fig. 3 - The system model of artificial neural network for input, hidden and output layer [18].

BARS score. From these input representations, only significant variables will be selected into the system.

Each neuron in the hidden layer of the networks can generally be considered as a simple processing element taking one or more inputs and giving one or more outputs. The number of hidden layer neurons will be determined through trial and error since no accepted theory currently exists for predetermining the optimal number of hidden layer neuron [19].

The number of hidden layer neurons will be selected to lead to a predictive network with the best sensitivity and specificity. This kind of method also had been used by Azmi et.al. and Adib et. al. in their engineering researches [20-21]. The developed prediction model generated the probability value for neurobehavioral deterioration from the output node. The probability value will be calculated for each actual data. The performance of the prediction model developed in this study will be evaluated in the validation set.

The last process will be the development of a software program prototype. It involves the designing the graphical user interface (GUI), coding writing, and algorithm development and verification test on the prototype.

3. Statistical Analysis

Descriptive statistics will be utilized to examine the output from the pilot study and case study. The factors will be broke down by utilizing the mean (X), standard deviation (SD), range and percentage (%) vile upon on the risk factor score. While for the questionnaire results, for each part of the questionnaire will be analysed for their mean (X), Standard deviation (SD) and percentage (%). The bar chart will be used to illustrate the result obtained.

The Chi-squared analysis will be used to determine the relationship between the neurobehavioral score, heavy metal concentration, working history, and other variables involve. The null hypothesis for these tests will be if the value of p (Pearson Shi-Square) (.000) is less than the predominant alpha value (.05/2 = .025), then there is a significant association between the heavy metal concentration in the worker's body and the neurobehavioral score. This conclusion will be made at the significant level of α=.05 (5%) of the confidence level at 95%. The statistical analysis will be performed by using the SPSS for Windows version 23 software.

Conclusions

Through this study, it is expected that a new neurobehavioral risk prediction model on detection on early symptoms of neurobehavioral deterioration will be developed. Hence, it can contribute to a better understanding of the effects of heavy metals exposure, especially to central nervous systems among welders in Malaysia. Results from the study will help in enhancing the safety through the law, legislation, health communication strategies or risk assessment intervention where such data needed. The developed prediction model will fulfil the needed of public, safety practitioners, personal of citizen group or governmental officer to determine the exposure of toxicant elements which can lead to the reduction of human health and drive to central nervous system related diseases such as Alzheimer, Parkinsonism, Manganism and many more.

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