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Exposure assessment, a preventive process in managing workplace safety and health, challenges in Ghana

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ABSTRACT

Exposure assessment is a strategy for anticipating, recognizing and evaluating employee exposures to physical, chemical, biological and ergonomic stresses at the workplace, so that effective and "sensible" controls can be put in place to mitigate the risk of occupational injury or occupational illness to the worker. It has been unveiled by this paper that this process is not applied adequately in Ghana and hence, hazards are not properly identified at workplaces. This leads to misapplication of controls or application of inadequate controls which tend not to reduce the risks at workplace. This outlines the various applicable exposure assessment strategies and also recommend controls and conditions that will make the process work in Ghana. It was outlined also that the process starts with the basic characterization which included area characterization, agent characterization and workforce characterization. This helps the industrial safety professional to understand the Similar Exposure Groupings (SEG's) and their corresponding exposure profiles. This makes use of the basic statistics of the sample sizes of the SEG's which get projected to the populations with 95% confidence interval so as to finalize tolerable risks. The modern engineer, the medic, and all relevant professionals must be conversant with this process and hence apply it at the workplace to ensure prevention of adverse exposures to employees, as well as prevention of accidents at the workplace.

1. Introduction

Ghanaians working in different professions and industries are subjected to different work environment conditions and hence different agents to different levels. Due to personal differences in human physiology and health resistance, different people being exposed to the same agent would have different susceptibility hence different extents of health effect.

The study of job role requirements and the personnel's ability to perform such tasks is referred to as Job Capability Assessment (JCA). The exposure assessment and job capability assessment are conducted in parallel and this leads to the establishment of groups of workers whose job functions require similar physical effort, and are normally exposed to similar agents at similar levels under the same control. These groups are referred to as Similar Exposure Groups (SEG's), and when conducting exposure assessments, a sample is selected from the SEG for the analysis and the results are projected onto the entire population of the SEG. Decisions made on the SEG's as a result of the exposure assessment are applicable to all persons in the group.

To be able to conduct a thorough exposure assessment, the workplace layout must be understood properly and this must encompass locations of all the types of the unit operations and tasks that take place in different environments. This assessment of the work area is considered area characterization.

The second important step required for an effective exposure assessment is identification of physical, chemical, biological and psychosocial stresses in the workplace, their existing controls, the extents to which they exist in the workplace and their nature. This exercise is known as agent characterization.

A third component of exposure assessment requires the understanding of the demography of the workforce, their strengths and weaknesses, job roles, the effort required for the specific tasks, medical history of the employees which is collected from pre-employment and periodic medicals. Collection of such information

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helps in grouping the workforce under a process called workforce characterization.

The three processes above (Workplace Characterization, Agent Characterization and Workforce Characterization) combined is referred to as Basic Characterization. The results of the basic characterization are used for risk assessment and this helps organizations to identify acceptable risks, unacceptable risks and uncertain risks. Acceptable risks get re-assessed only after a scheduled duration, but with unacceptable risks, appropriate controls are sought for and fixed to mitigate them to tolerable levels. With regards to uncertain risks, further information would have to be collected until there is adequate information, which will help, understand the risk profile. In all the three possible outcomes, the results get looped back into Basic Characterization. The entire process of the exposure assessment can be summarized as shown in Fig. 1.

Once this process is completed properly, the outcome helps organizations to implement controls that mitigate risk exposure to workplace agents and hence ensuring the safety of the workforce.

Therefore, the main goal of this present paper is to outline the various applicable exposure assessment strategies and also recommend controls and conditions that will make the process work better in Ghana and further provide a detailed risk matrix with its corresponding analysis revealing the various acceptable and unacceptable risks.

2. Exposure assessment implementation and challenges in Ghana

As explained by Annan (2010), the Ghanaian employee's exposure to physical, chemical, biological and psychosocial workplace stress is in ascendancy due to the general trend in increasing rate of industrialization in the nation. Challenges inhibiting the progress of workforce characterization are associated with the availability of appropriate personal health information. As confidential as medical information can be, employee's medical history is critical in determining his/her capability of performing future functions.

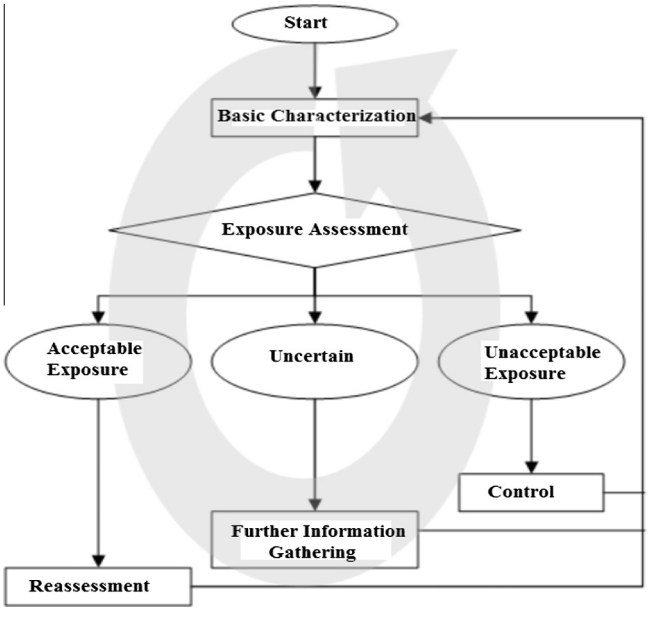

Fig. 1. Strategy for assessing and managing occupational exposures (AIHA, 2006).

Hardly do employers in Ghana refer to medical history from previous employers if they want to actually conduct pre-employment medicals in Ghana. Also, due to insufficient or lack of occupational health physicians in the country, the criteria for pre-employment medicals is subjective, and varies from practitioner to practitioner. Existence of occupational health services in the country is a question not yet answered (Clarke, 2005), hence the workforce characterization at work places is a challenge which is yet to be addressed in Ghana.

During "Agent Characterization", employers are expected to anticipate, recognize, evaluate and control the physical, chemical and biological agents (Annan, 2010), the professionals (Occupational Hygienists or Industrial Hygienists) with the skill set to accomplish this step are less than five in the entire country. In addition, no educational institution in Ghana runs an accredited degree program in Safety Engineering or related courses. This challenge poses a lack of adequate skill required for the completion of a comprehensive exposure assessment and risk mitigation.

The nation has not got enough standards to serve as the basis for rating risks of employee exposures at the workplace. For instance, if we consider a typical Ghanaian mine worker at Assay Laboratory, there is a potential for exposure to lead fumes or dust. To understand the risk of such an exposure, the levels need to be known and evaluated as above acceptable limit or not, however, what we call acceptable or not acceptable is not known. Reference can be made to the American Industrial Hygienists Association Threshold limit value, or National Institute of Occupational Safety and Health recommended exposure levels or the OSHA permissible exposure levels or the British EH 40 just to mention a few, but these are different values for different purposes, but Ghana has not yet developed standards in this regard and this area still remains as a challenge.

During agent characterization, one of the most important sources of information is the material safety data sheet. In Ghana, a lot of the products do not have material safety data sheets (MSDS). The suppliers hardly request for the MSDS's when importing chemicals and hazardous materials. This leaves a significant gap in the information required to be able to understand risks associated with exposures to chemicals, hence the inability to determine appropriate controls to mitigate such risks.

For physical agents such as noise, vibration and heat, the nation has insufficient standards pertaining to Occupational Safety and Health. The Ghana Environmental Protection Agency (GEPA) (2007) has some environmental standards, but these cannot replace the required Occupational Safety and Health standards. For example, Ghana EPA has a requirement for noise exposure levels, but this is not defined by exchange rate, criterion level and response rate, which are parameters used in noise exposure assessment. Generally, due to the lack of sufficient standards, completing the exposure assessment in Ghana remains a challenge. This challenge affects the ability to conduct effective characterization of agents and hence risk assessment and control. Effective management of Occupational Safety and Health is therefore impeded under this circumstance.

As far as classification of risks is concerned, most occupational exposure risks remain uncertain, hence further information for gathering is required as presented in Fig. 1. This process is, however impeded by lack of resources. In this case, the groups with uncertain workplace exposures remain very significant in Ghana, hence the inability to spend effort ranking and prioritizing these exposures, hence the inability to fix appropriate controls.

Confusing application of health effects rating systems is a potential source of misclassification of occupational exposure risks, hence the inability to evaluate appropriate controls to mitigate them. For instance, according to the Council of European Communities, the European Union (EU) (GHS ST/SG/AC.10/30/Rev2, 2007) has

Table 1
Agents and the required exposure assessment (CFR, 1910; CFR, 1910 and 1926).

Agent	Exposure assessment requirements
Lead	Work shift & short-term monitoring of representative employees and tasks; Initial, quarterly, semiannually, or annually; Objective data permitted
Asbestos	Initial exposure assessment prior to initiating work; Work shift & excursion monitoring; Daily & periodic depending on work classification; Objective data permitted
Inorganic Arsenic	Work shift monitoring; Quarterly or annually depending on concentration
Benzene	Work shift and short-term monitoring each job classification and work area; Initial, semiannual and annual (time of year may be prescribed)
Cadmium	Work shift monitoring of representative employees and tasks; Initial and semi annually
Acrylonitrile	Work shift monitoring; Initial and monthly or quarterly depending on concentration
Ethlene oxide	Work shift & short-term monitoring each job classification and work area; Initial, quarterly and semi annually
Formaldehyde	Work shift & short-term monitoring of representative employees and tasks; Initial, semiannual and annual; Objective data permitted for negative determination.
Butadiene	Work shift & short term monitoring of representative employees and tasks; Initial, quarterly, semiannual or annual; Object data permitted
Noise	Area & personal monitoring to determine employee exposure
Respiratory protection	Exposure assessment that includes a reasonable estimate of employee exposure
HAZWOPRER	Requires design of an exposure assessment program as part of the Site-Specific Safety and Health Plan
Laboratories	Requires a *Chemical Hygiene Plan* and an exposure assessment
Dip tanks	Requires evaluation of probable skin contact and effectiveness of airborne contaminant control measures
Abrasive blasting	Evaluation of dust hazards from abrasive blasting
Ionizing radiation	Exposure assessment required

established standard toxicity classifications for use on labels. The National Fire Protection Association (NFPA) standards and the Hazardous Material Identification System (HMIS) are used in the United States, and the Bodily Impact Rating (BIR) developed by Pfizer used by Union Carbide (NFPA 400, 2015). The question is, "what classification system do we use in Ghana?" (Annan et al., 2015), occupational health specialization is not found in the Ghanaian medical schools, hence most – if not all – Ghanaian trained medical doctors have very little or no knowledge about these processes. The lack of knowledge still leaves us with the inability to complete effective occupational exposure assessment, risk prioritization and control, hence ineffective management of Occupational Safety and Health in the country. A list of agents as well as their requirement for exposure assessment is provided as shown in Table 1.

3. Recommendations

The basis of all Occupational Safety and Health standards in Ghana need to be dependent on, and be driven by a national Occupational Safety and Health Policy. Ghana must develop or adopt a policy in Occupational Safety and Health with specific applicable objectives, responsibilities and accountabilities. This must show the Government's commitment and leadership in the implementation.

Managing Occupational Safety and Health must be approached from a multi-disciplinary perspective, as shown in Fig. 2.

To be able to run an effective safety and health program, there has to be a reason for implementing specific management systems. The different roles come together to ensure an effective achievement of the Occupational Safety and Health goals. The industrial or occupational hygienist ensures the completion of exposure assessment, and the results are used to determine the types of controls that are required to be put in place to ensure a good safety management system. At this initial stage, a thorough engineering risk assessment is required to be completed, and tools like Hazard and Operability Study (HAZOPS), Failure Mode Effect and Analysis (FMEA), Fault Tree Analysis (FTA) and other applicable tools get used to identify hazards and failure probabilities and potential consequences. The outcome of this process aids the identification of specific elements of safety management systems to be used. This also aids the organization to develop an effective health management system based on risk. The occupational health management system must be in line with the operational requirements to ensure prevention of occupational illnesses and injuries, as shown in Figs. 3a and 3b.

The outcomes of step 1 in Fig. 3a are used in step 2 of the process to conduct the health risk assessment. The risk is determined by the product of the probability of exposure and the potential consequence. This is shown in the Eq. (1). In this context, risk could be explain as the probability that damage to life, health, and/or the environment will occur as a result of a given hazard (such as exposure to a toxic chemical). Some risks can be measured or estimated

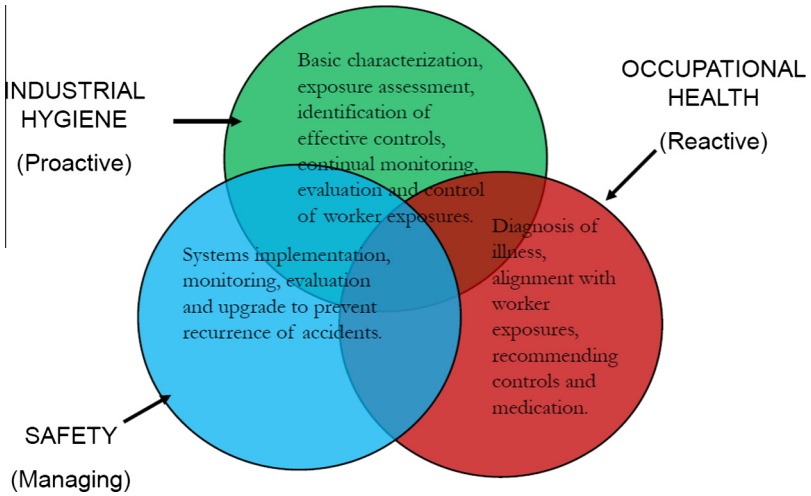

Fig. 2. Managing Occupational Safety and Health in Ghana.

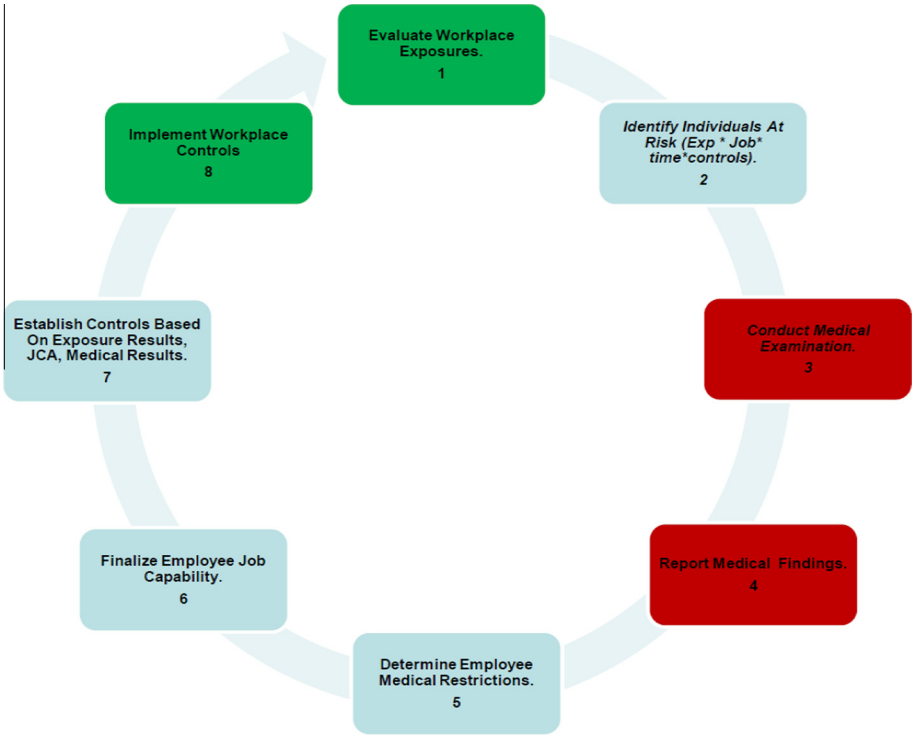

Fig. 3a. Elements of proactive management of occupational health and hygiene.

in numerical terms (e.g., one chance in a hundred). The risk or probability of injury or ill-health resulting from a hazard(s) is a factor not only of the inherent nature of the hazard, but also of the controls in place to mitigate the hazards. Risk assessment is therefore explain as an organized process used to describe and estimate the amount of risk of adverse human health effects from exposure to a toxic chemical or other hazard (how likely or unlikely it is that the adverse effect will occur). How reliable and accurate this process depends on the quantity and quality of the information that goes into the process.

$$\text{Risk} = \text{Consequence} * \text{Probability} \quad (1)$$

The likelihood of exposure can be estimated from the Eq. (2) below.

$$\text{Probability} = \frac{\text{Exposure} * \text{Frequency} * \text{Duration} * \text{Number of People}}{\text{Controls}} \quad (2)$$

Knowing the ratings for the likelihood and the potential consequence, risk ranking could then be determined from a risk matrix as shown in Table 2. The various steps of probability of occurrences as well as the potential consequence are presented. The hierarchy of risk ranging from least low to extreme high is also depicted.

Table 3 explains the various ranges of likelihood and their resulting consequence. For example, a consequence of immediate irreversible effects, resulting in a permanent disability or death corresponds to the likelihood of certain. While Table 4 discussed the various actions needed to minimize such risk.

Based on the risk matrix discussed in Table 2, the various levels of risk can therefore be categorized into acceptable and unacceptable as shown in Fig. 4 with detail explanation illustrated below;

- Risks towards the top right corner are of critical importance. They are the top priorities which needs very close attention.
- Risks in the bottom right corner are of high importance if they do occur, but they are very unlikely to happen. Method to reduce the consequence needs to put in place if they occur.

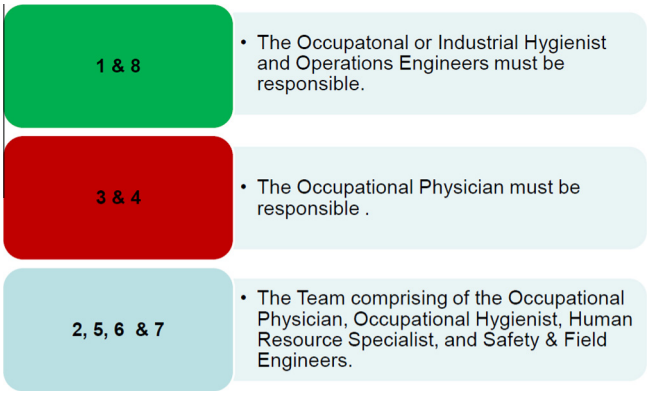

Fig. 3b. Roles required in completing the stages in Fig. 3a.

- Risks in the top left corner are of moderate importance, in case it occurs, it could be coped with. However, the likelihood of occurrence needs to be reduced.
- Risks in the bottom left corner are low level, in normal condition, it could be ignored.

Knowing the ranks of health risks, the occupational health physicians, safety engineers and employers can then know what is required to be investigated during pre-employment and periodic medicals in step 3 of Fig. 3a. Findings from these stages of the health risk assessment are used to determine specific job capability requirements, and controls are then put in place to ensure that minimal exposures are encountered by workforce during work.

Understanding the above process is still a challenge in Ghana among engineers, medical doctors and the academia, hence, there is little information pertaining to managing Occupational Safety and Health in Ghana from this perspective. This gap goes back to the lack of national policy and commitment in Occupational Safety and Health, hence it is commendable that the nation develops or

Table 2
Risk matrix ranking.

Probability	Consequences				
	Insignificant	Minor	Moderate	Major	Catastrophic
Certain (80–100%)	Low Risk	Moderate Risk	High Risk	Extreme Risk	Extreme Risk
Likely (61–80%)	Least Risk	Low Risk	Moderate Risk	High Risk	Extreme Risk
Possible (41–60%)	Least Risk	Low Risk	Moderate Risk	High Risk	High Risk
Unlikely (21–40%)	Least Risk	Low Risk	Low Risk	Moderate Risk	High Risk
Rare (1–20%)	Least Risk	Least Risk	Low Risk	Moderate Risk	Moderate Risk

Table 3
Range of probability and their consequence.

Range	Consequence
Certain	Immediate irreversible effects resulting in permanent disability or death.
Likely	Major – chronic irreversible illness resulting in permanent disability or death
Possible	Moderate – severe reversible effects; agents with good warning properties
Unlikely	Minor – reversible health effects requiring treatment
Rare	Nuisance value – minor reversible health effects

Table 4
Risk levels as well as actions to minimize it.

Risk level	Priority	Actions to minimize risk
Extreme high	1	Detailed research and planning required; determine whether an activity or task should be stopped pending further investigation
High	2	Senior management attention; immediate corrective and preventative action plan required
Moderate	3	Conditionally acceptable risk – management responsibility assigned; corrective and preventative action plan developed.
Least and low risk	4	Manage by routine procedures; accept risk

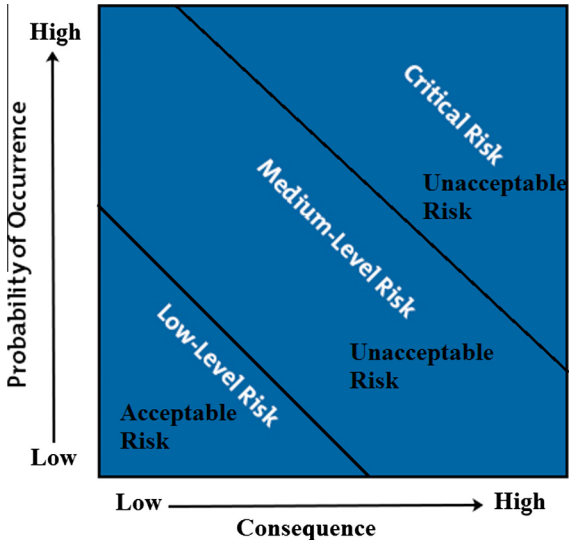

Fig. 4. categorizing risk levels according to acceptable and unacceptable.

adopts a policy, based on which standards will be developed and academic programs can also be developed to reflect the content of the policy. This will lead to an across board implementation of Occupational Safety and Health standards in the nation, which will protect the Ghanaian worker and the employer as well. Exposure assessment is obviously a preventive tool for managing Occupational Safety and Health, however, all these challenges in Ghana are yet to be identified and addressed.

4. Conclusion

The increasing industrialization in Ghana is with no doubt, leading to increasing numbers of our Ghanaian working population being exposed to workplace physical, chemical, biological and psychosocial stressors.

Exposure assessment is a strategy for anticipating, recognizing, evaluating and controlling employee exposures, so that effective and "sensible" controls can be put in place to mitigate the risk of occupational injury or illness. This is a critical objective of a good workplace Safety and Health Management system.

There is no doubt that the inadequate application of this process contributes to inefficient management of workplace health and safety in the country. Employers have very little information about what the country expects them to do so as to ensure effective management of workplace safety and health, the nation has not gotten specific standards on what employers and employees should meet in order to ensure acceptable management of Occupational Safety and Health. It definitely unclear to the Ghanaian worker, what is considered safe and that which is considered unsafe.

As explained in Annan et al. (2015), the nation has fragmented legal requirements under the jurisdictions of different Government agencies but there is no Government body mandated to monitor, manage and control the Occupational Safety and Health systems across all industries in the nation. The existing gap of not having ratified the ILO convention 155 (Labour Organization/World Health Organization (ILO/WHO) ILO, 2005), and having no national policy on Occupational Safety and Health remains a challenge which, if not solved, will keep the dream of effective management of Occupational Safety and Health in the country a fleeting illusion never attained.

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