COURSE GUIDE

PHS 404
OCCUPATIONAL HEALTH AND SAFETY

Course Team

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INTRODUCTION

This course, *PHS 404 Occupational Health and Safety* is a three-credit unit course. Occupational health and safety deals with the study of the basic elements in occupation including the worker, the tools, the process and the work environment. This is done to ensure proper arrangement of these critical elements in order to maintain and protect the health and well-being of the worker and that of the environment. Occupational health experts are interested in conditioning and controlling the work environment in order to ensure that no worker's health is compromised as a result of his/her engagement in assigned task. Beyond assigned task, experts are also interested in making the work environment stimulating for positive health behaviour as this engenders optimal health which in turn is needed to maximize work output.

Every worker has a right to life and this right is threatened when the work environment and the work itself increases risk of disease, injury, accident or death. Occupational health and safety as a practice and discipline is historically tied to the Industrial Revolution in the early part of the 18^{th} Century. The Industrial Revolution is a turning point in occupational health as it led to industrialization which in turn necessitated formal relationship between an employee and the employer. The harsh and unhealthy working conditions to which workers, notably, women and children were being exposed to, led to agitations for occupational health and safety.

Occupational health has today become a vital discipline and field of study in Public Health and Community Medicine. Industries that make efforts to improve on the working conditions of workers benefit from different angles. The first is that it reduces the number of absenteeism and occupational ill-health induced sick leave. Organizations that make efforts to promote and maintain the health status of their workers spend nothing or little in compensations due to injuries resulting from the working tools, processes or the working environment. Above all, it is important to note that industries where occupational health and safety is prioritized have better work output as a result of optimal performance of workers. When workers' health is protected, their output is maximized to resulting in organizational growth and development. This course centres on protecting, maintaining and improving the health and well-being of workers in their work environment.

WHAT YOU WILL LEARN IN THIS COURSE

Occupational health and safety is an interesting course as it applies to everyday life and living. Every individual is involved in some kind of work. The knowledge to be drawn from this course is therefore useable and not residual. Its contents are not abstract but practical and depiction of what obtains in every industrial setting. It must be noted that the word ‘industry’ does not literally translate to a factory or industry but any work setting.

There is no industry that does not have occupational health hazards and risk that endanger the health and wellbeing of workers in that setting.

Occupational health and safety is not restricted to industries using heavy machineries or toxic chemicals alone but to every work setting involving some levels of muscular contraction even from a static position. So open up our mind and enjoy the stimulating and thought provoking contents of the course. This is in order to enable you acquire functional knowledge and skills that will help you protect your health in the work environment. In the same vein, this knowledge and skill will also empower you to discharge the role of a safety personnel and resource person in occupational health and safety.

COURSE AIM

The overall aim of this course is to instil functional knowledge, develop positive attitude and empower students with skills that will enable them to effectively discharge duties as occupational health and safety personnel and resource persons in issues relating to occupational health and safety.

COURSE OBJECTIVES

It is expected that at the end of this course, students should be able to:

- Define and explain the concept of occupational health
- State at least five objectives and five principles of occupational health
- Narrate a historical account of the development of occupational health with central focus on the Industrial Revolution in England
- Define hazard and make a distinction between hazard and risk
- Explain occupational hazards and the process of identifying them
- State the classification of occupational hazards using relevant examples in each class

- Explain how to prevent the manifestation of each class of occupational hazards.
- Define occupational anatomy and physiology
- Explain work fatigue and how to measure work performance
- Explain toxicology in relation to work environment
- Identify the portal of entry of toxic substances into the human system
- Identify factors influencing toxicity
- Explain epidemiology in occupational health
- List and explain determinants of occupational health problems
- List and explain occupational health problems affecting different organs and systems in humans
- Explain how to evaluate occupational health problems
- Explain how to prevent occupational health problems an diseases

WORKING THROUGH THIS COURSE

This course is carefully organized and planned taking cognizance of the fact that it might be strange to you. Adequate and simple explanations and illustrations are made to help you navigate through and understand every concept covered in the course. The course developers took out time to ensure that you are not burdened with unnecessary details concerning occupational health. Distinct and requisite contents that would empower you with knowledge and skills to function effectively in every tasks requiring sound and accurate knowledge of occupational health are covered in simple and concise style.

Although the course has been designed to support independent study, attending tutorial sessions will greatly enhance understanding of concepts discussed in the course as it will avail your opportunity to ask relevant questions to further your understanding. Studying the course resources and attending tutorial sessions are vital to enhancing not only your grade but your understanding and usability of the knowledge garnered from the course.

COURSE MATERIALS

This course comprises eight modules broken down into 42 different units. They are as listed below:

i. A course guide
ii. Study units

STUDY UNITS

Module 5 Occupational Toxicology

Unit 1 Meaning of Occupational Toxicology
Unit 2 Portal of Entry for Toxic Chemicals
Unit 3 Dose-Response Relationship and its Assessment
Unit 4 Health Effects of Toxicology
Unit 5 Health Effect of Toxic Chemicals
Unit 6 Factors Influencing Toxicity
Unit 7 First Aid for Toxic Chemicals

Module 6 Epidemology of Occupational Health Problems

Unit 1 Epidemiology of Occupational Diseases and Injuries
Unit2 Determinants of Occupational Diseases and Injuries
Unit3 occupational Disorders Based on Target Systems/Organs
Unit4 Evaluating Workplace Disability and Compensation System

Module 7 Evaluation of Occupational Disorders and Safety

Unit 1 Concept of Evaluation in Relation to Occupational Health
Unit 2 Air Quality Assessment in Occupational Health
Unit 3 Work Environment and Worker Assessment
Unit 4 Health Surveillance and Biological Management
Unit 5 Measurement of Occupational Hazards

Module 8 Preventing and Controlling Occupational Diseases, Injuries and Disorders

Unit 1 Concept of Prevention and Control of Occupational Health Problems
Unit 2 Hierarchy of Prevention and Control Methods

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ASSIGNMENT FILE

There are two components of assessment for this course. They are the tutor-marked assignment and the final examination.

TUTOR-MARKED ASSIGNMENT

This is the continuous assessment component of this course. It accounts for 30 percent of the total score. The tutor marked assignment will be given to you by the course facilitator and you will return it after completing the tasks.

FINAL EXAMINATION AND GRADING

The final examination is the concluding assessment for the course. It constitutes 70 percent of the whole course. You will be duly informed of the time for the examination.

SUMMARY

This course is designed to impact functional knowledge of occupational health and safety to you. This knowledge, being functional, is expected to empower you to take up any role involving occupational health and discharging it with excellence. We wish you success in this course and hope that you will translate the knowledge gained to becoming a solution in occupational health problems.

MAIN COURSE

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MODULE 1 CONCEPT OF HEALTH AND OCCUPATIONAL HEALTH

CONTENTS

1.0 INTRODUCTION

This module covers an introductory aspect of the course beginning with an overview of the concept of health, dimensions of health and determinants of health. It also encompasses an introduction of the core of the course – occupational health, aims and objectives of occupational health, rationale for occupational health, key principles of occupational health and basic concepts used in occupational health.

2.0 OBJECTIVES

At the end of this module, you should be able to:

- Define health and state its dimensions
- State at least five determinants of health
- Define occupational health
- State at least five aims and objectives of occupational health
- State the general rationale for occupational health
- Mention at least seven key principles of occupational health
- State and explain at least five basic concepts in occupational health

3.0 MAIN CONTENT

3.1 Concept of Health, its Dimensions and its Determinants

Health remained an elusive concept until 1948 when the World Health Organisation (WHO) proposed a definition that dismissed the erroneous biomedical model of health that held sway. The WHO (1948) defined health as "a state of complete physical, mental, andsocial well being and not the mere absence of disease orinfirmity". Although this definition attracted many criticisms, it remains the most widely quoted and popular definition of health.

Dimensions of Health
Based on the proposition of health by WHO (1948), three dimensions of health have been identified namely, physical, social and mental health dimensions. These dimensions are briefly described below:

***Physical Health*:** This dimension of health refers to the anatomical integrity and optimal physiological functioning of the body. A person with physical health will exhibit the following attributes:

- All the body parts are present, complete and functional,
- All the body parts are in their natural place and position
- None of the body parts has any form of pathology
- All the body parts operate at optimal physiological functions
- All the body parts work with each other in a near perfect harmonious manner

***Mental Health*:** This dimension refers to ability to learn and think clearly. A person with good mental health is able to handle day-to-day events and obstacles, worktowards important goals, and function effectively in society.

***Social Health*:** This is the ability to make and maintain acceptable interactionswith other people. Park (2013) defined it as the ability to be at peace with self and with others around.

A major advantage of the conception of health by the WHO (1948) is dispelling the biomedical model of health that viewed health as absence of disease. An individual might not have any form of disease and yet operate at a very low level of health as the social and mental dimensions might be affected even if the physical dimension is perfect. Without the conceptualization of the WHO, one cannot dispel the fact that a mad man on the street is healthy. This is because insanity has nothing to do with anatomical and physiological functioning but with the mental aspect in which the mad person has lost touch with reality.

3.2 Concept of Occupational Health

According to the WHO (2001), occupational health is a multidisciplinary activity aimed at the protection and promotion of the health of workers by preventing and controlling occupational diseases and accidents and by eliminating occupational conditions and factors hazardous to health and safety at work. It also connotes development and promotion of healthy and safe work, work environments and work conditions. Occupational health, according to the WHO (2001) also refers to the enhancement of the physical, social and mental well-being of workers and support for the development and maintenance of their working capacity as well as professional and social development at work. It is also an activity concerned with enabling workers to lead socially and economically productive lives and to contribute positively to sustainable development.

The International Labour Organisation (ILO/WHO) defined occupational health as the "promotion and maintenance of the highest degree of physical, mental and social well- being of workers in all occupation." According to the WHO, the health of every worker and if possible, that of his/her family members should be the responsibility of the organisation he/she is working for.Ogundele (2017) defined occupational health as the science of anticipating, recognizing, evaluating and controlling of health hazards and risk arising in or from the work environment with the objectives of protecting the health and well-being of workers and the surrounding. According to the scholar, it is an interdisciplinary field that focuses on preventing and controlling occupational illnesses and injuries.

Occupational Health is a diverse science applied by occupational health professionals engineers, environmental health practitioners, chemists, toxicologists, doctors, nurses, safety professionals and others who have an interest in the protection of the health of workers in the workplace.Successful occupational health and safety practice requires the collaboration and participation of both employers and workers in health and safety programmes, and involves the consideration of issues relating to occupational medicine, industrial hygiene, toxicology, education, engineering safety, ergonomics, psychology, etc.

Occupational health issues are often given less attention than occupational safety issues because the former are generally more difficult to confront. However, when health is addressed, so is safety, because a healthy workplace is by definition also a safe workplace. The converse, though, may not be true - a so-called safe workplace is not necessarily also a healthy workplace. The important point is that issues of both health and safety must be addressed in every workplace. By and large, the definition of occupational health and safety given above encompasses both health and safety in their broadest contexts.

Components of Occupational Health

Occupational health as a discipline covers the following key components:

1. Availability of occupational health and safety regulationsat workplace
2. The availability of active and functional occupational health and safety committee at workplace
3. Monitoring and control of factory hazards to health
4. Supervision and monitoring of hygiene and sanitary facilitiesfor health and welfare of workers
5. Inspection of health safety of protective devices
6. Pre-employment, periodical and special health examination.
7. Performance of adaptation of work to man
8. Provision of First Aid
9. Health education and safety training for the workers
10. Advice to employers on how to cater for the health of their workers
11. Reporting of occupational deaths, diseases, injuries, disabilities, hazards and their related preventive measuresat working

3.3 Aims of Occupational Health

Occupational health and safety is a discipline with a broad scope involving many specialized fields. In its broadest sense, it aims at:

- The promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations;
- The prevention among workers of adverse effects on health caused by their working conditions;
- The protection of workers in their employment from risks resulting from factors adverse to health;
- The placing and maintenance of workers in an occupational environment adapted to physical and mental needs;
- The adaptation of work to humans.
- To prevent occupational accidents and illness
- To defend the workers health and safety
- To avoid any possible accidents and risks in the workplace
- To inform and give advice to the workers

- To train company representatives and employees get some ideas from them
- And make sure that they attend those training programmers To protect the workers because of their age, gender and special problem and
- Rearrange the rules and regulations for them, assess workplace compliance with rules and regulations applied

Effects of Poor Working Conditions on Workers' Health and Safety

Poor working conditions of any type have the potential to affect a worker's health and safety.Unhealthy or unsafe working conditions are not limited to factories — they can be found anywhere, whether the workplace is indoors or outdoors. For many workers, such as agricultural workers or miners, the workplace is "outdoors" and can pose many health and safety hazards.Poor working conditions can also affect the environment where workers live in, since the working and living environments are the same for many workers. This means that occupational hazards can have harmful effects on workers, their families, and other people in the community, as well as on the physical environment around the workplace. A classic example is the use of pesticides in agricultural work. Workers can be exposed to toxic chemicals in a number of ways when spraying pesticides: they can inhale the chemicals during and after spraying, the chemicals can be absorbed through the skin, and the workers can ingest the chemicals if they eat, drink, or smoke without first washing their hands, or if drinking water has become contaminated with the chemicals.

The workers' families can also be exposed in a number of ways: they can inhale the pesticides which may linger in the air, they can drink contaminated water, or they can be exposed to residues which may be on the worker's clothes. Other people in the community can all be exposed in the same ways as well. When the chemicals get absorbed into the soil or leach into groundwater supplies, the adverse effects on the natural environment can be permanent. The most important point to note is that efforts in occupational health and safety must aim to prevent industrial accidents and diseases, and at the same time recognize the connection between workers' health and safety, the workplace, and the environment outside the workplace.

3.4 Rationale for Occupational Health

Work plays a central role in people's lives, since most workers spend at least eight hours a day in the workplace, whether it is on a plantation, in an office, factory, etc. Therefore, work environments should be safe and healthy. Yet this is not the case for many workers. Every day workers all over the world are faced with a multitude of health hazards, such as:

- Dusts;
- Gases;
- Noise;
- Vibration;
- Extreme temperatures.

Unfortunately some employers assume little responsibility for the protection of workers' health and safety. In fact, some employers do not even know that they have the moral and often legal responsibility to protect workers. As a result of the hazards and a lack of attention given to health and safety, work-related accidents and diseases are common in all parts of the world (ILO, 2017).

Cost of Occupational Injuries and Diseases

Work-related accidents or diseases are very costly and can have many serious direct and indirect effects on the lives of workers and their families. For workers some of the direct costs of an injury or illness are:

- The pain and suffering of the injury or illness;
- The loss of income;
- The possible loss of a job;
- Health-care costs.

It has been estimated that the indirect costs of an accident or illness can be four to ten times greater than the direct costs, or even more. An occupational illness or accident can have so many indirect costs to workers that it is often difficult to measure them. One of the most obvious indirect costs is the human suffering caused to workers' families, which cannot be compensated with money.

The costs to employers of occupational accidents or illnesses are also estimated to be enormous. For a small business, the cost of even one accident can be a financial disaster. For employers, some of the direct costs are:

- Payment for work not performed;
- Medical and compensation payments;
- Repair or replacement of damaged machinery and equipment;
- Reduction or a temporary halt in production;
- Increased training expenses and administration costs;
- Possible reduction in the quality of work;
- Negative effect on morale in other workers.

Some of the indirect costs for employers are:

- The injured/ill worker has to be replaced;
- A new worker has to be trained and given time to adjust;
- It takes time before the new worker is producing at the rate of the original worker;
- Time must be devoted to obligatory investigations, to the writing of reports and filling out of forms;
- Accidents often arouse the concern of fellow workers and influence labour relations in a negative way;
- Poor health and safety conditions in the workplace can also result in poor public relations.

Overall, the costs of most work-related accidents or illnesses to workers and their families and to employers are very high.On a national scale, the estimated costs of occupational accidents and illnesses can be as high as three to four per cent of a country's gross national product. In reality, no one really knows the total costs of work-related accidents or diseases because there are a multitude of indirect costs which are difficult to measure besides the more obvious direct costs.

3.5 Key Principles of Occupational Health

Notable key principles underlie the field and practice of occupational health and safety. These principles according to Ali (2008) are designed to achieve the overall objective of occupational health which is the fact that work should take place in asafe and healthy environment. Key principles as documented in Ali (2008) are briefly discussed below:

1. *All workers have rights*:Every worker has a right to life and safety. Workers, as well as employers and governments,must ensure that these rights are protected and must strive to establishand maintain decent working conditions and a decent working environment.More specifically these conditions as listed by the International LabourOrganisation (1984) must be ensured:

   - work should take place in a safe and healthy working environment;
   - conditions of work should be consistent with workers' well-beingand human dignity;
   - work should offer real possibilities for personal achievement, self-fulfilmentand service to society.

2. *Occupational safety and health policiesmust be established*: Thesepoliciesmustbe implemented at both the national (governmental) and enterprise levels.They must be effectively communicated to all parties concerned.
3. *A national system for occupational safety and health must be established:* Such a system must include all the mechanisms and elements necessaryto build and maintain a preventive safety and health culture. The nationalsystem must be maintained, progressively developed and periodicallyreviewed. How this is true in the case of the Nigerian Labour Congress (NLC) and Trade Union Congress (TUC) is highly doubtful.
4. *A national programme on occupational safety and health must beformulated*. Once formulated, it must be implemented, monitored,evaluated and periodically reviewed.
5. *Stakeholders must be involved in policy formulation*: This should be done during formulation, implementationand review of all policies, systems and programmes.
6. *Occupational health programmes must aim at bothprevention and protection*: Efforts must be focused above all on primaryprevention at the workplace level.Workplaces and working environmentsshould be planned and designed to be safe and healthy.
7. *Continuous improvement of occupational safety and healthmust be promoted*: This is necessary to ensure that national laws, regulations and technicalstandards to prevent occupational injuries, diseases and deaths are adaptedperiodically to social, technical and scientific progress and other changes inthe world of work. It is best done by the development and implementationof a national policy, national system and national programme.
8. *Information is vital for development and implementation of effectiveprogrammes:*The collection and dissemination of accurateinformation on hazards and hazardous materials, surveillance ofworkplaces, monitoring of compliance with policies and good practice,and other related activities are central to the establishment andenforcement of effective policies.
9. *Health promotion is a central element of occupational health practice:*Effortsmust be made to enhance workers' physical, mental and social well-being.
10. *Occupational health services covering all workers should be established:* Ideally, all workers in all categories of economic activity should haveaccess to such services, which aim to protect and promote workers'health and improve working conditions.

11. *Compensation, rehabilitation and curative services must be made availableto workers:* Action must be taken to minimize the consequences ofoccupational hazards.
12. *Education and training are vital components of safe, healthy working environments*: Workers and employers must be made aware of the importanceof establishing safe working procedures and of how to do so. Trainersmust be trained in areas of special relevance to particular industries, sothat they can address the specific occupational safety and health concerns.
13. *Policies must be enforced*: A system of inspection must be in place tosecure compliance with occupational safety and health measures andother labour legislation.

3.6 Basic Concepts in Occupational Health

There are four basic elements in the working environment. They are:

1. The worker
2. The tool
3. The process
4. The work environment

The worker

In developing countries like Nigeria, the work force has severaldistinct characteristics:

1. Most people who are employed to work in the informal sectors,mainly in agriculture, or in small-scale industries, such asgarages, tannery and pottery.
2. There are high rates of unemployment, some- times reaching 25% or higher. In many developing countries, the rates ofunemployment and under employment are increasing eachyear.
3. In general, workers are at greater risk of occupational hazardsfor a variety of reasons like unfamiliarity with work processes and exposures,inadequate training, predisposition not to complain aboutworking conditions or exposures because of jobs, whether ornot they are hazardous.

Workers are relatively scarce; experience high prevalenceof occupational diseases and malnutrition. There is also inadequate infrastructure and human resources to diagnose,treat, and prevent work - related diseases and injuries.

The Tool

Tools can range from very primitive tools like a hammer, chisel, andneedle, to automated equipment and other materials used for working.

The process

In the process, materials used can be toxic. The process itself canaffect the potential harmfulness of the materials. For example, theparticle size or physical state (solid, liquid and gas) of potentiallyharmful substances can determine to a large extent what ill effects inworkers may develop from those substances.

The work environment

Occupational environment means the sum of external conditions andinfluences which prevail at the place of work and which have abearing on the health of the working population. The industrialworker today is placed in a highly complicated environment and thework environment is getting more complicated as human isbecoming more innovative or inventive.

Interactions in the Working Environment

1. man and physical, chemical and biological agents.

a. The physical agents.
   These include excessive level of
   - Noise
   - Heat and humidity
   - Dust
   - Vibration
   - Electricity or lighting
   - Radiation etc.

b. Chemical agents.
   These arises from excessive air borneconcentrations of
   - Chemical dust
   - Mists
   - Fumes
   - Liquids
   - Vapors
   - Gases
   - Dust

c. The biological agents.
These include:
- Presence of insects and rodents
- Microorganisms
- Poisonous plants and animals

d. Ergonomic hazards
These include excessive improperlydesigned tools, work areas, or work procedures. Improper lifting orreaching, poor visual conditions, or repeated motions in an awkwardposition can result in accidents or illnesses in the occupationalenvironment.

2. Man and machine

An industry or factory uses power driven machines for the purposeof mass production. Unguarded machines, protruding and movingparts, poor electrical and machinery installation of the plant, and lackof safety measures are the causes of accidents. Working for longhours in an awkward postures or positions is the causes of fatigue,backache, diseases of joints and muscles and impairment of theworkers health and efficiency.

3. Man and his psychosocial environment

There are numerous psychosocial factors, which operate atworkplace. These are the human relationships among workersthemselves and those in authorities over them.

Examples of psychosocial factors include:-
- The type and rhythm of work.
- Work stability.
- Service conditions.
- Job satisfaction.
- Managers' leadership style.
- Job security.
- Workers` participation and communication.
- Motivation and incentives.

It is also important to state that the occupational environment of the worker cannot be consideredapart from his domestic environment. Both are complementary toeach other. The worker takes his worries to his/her home and bringto his work disturbances that has arisen in his/her home. Stress atwork may disturb his sleep, just as stress at home may affect hiswork.

Environmental Managers: occupational health personnelwho try to eliminate hazardsfrom the workplace cause many environmental problems.

Toxicology: is the science that studies poison and toxicsubstances and their mechanisms and effects on living organisms.In other words toxicology is the study of adverse effects of chemicalon biologic systems, or when a substance has a capacity to produceundesirable physiological effect when the chemical reached asufficient concentration at a specific site in the body.

Toxicologists: are persons who study poisoning and responsibledefining quantitatively the level of exposure at which harm occursand they also prescribe precautionary measures and exposurelimitations so that normal recommended use of chemical substancedoes not result in excessive exposure and subsequent harm

Ergonomics: is a multidisciplinary activity dealing with theinteraction between man and his total working environment plussuch traditional environmental elements as atmosphere, heat, light, and sound as well as all tools and equipment of the work place.

Chemical Engineers are those who design process plant, theychoose values, decide on how access will be gained and howcleaning will take place.

Mechanical Engineers are those who responsible for choosingmaterials handling systems or for specifying noise levels onmachinery.

Environmental Health Professionals: are those who apply theirknowledge and experience, understand the environmental healthhazards, analyze the technical and social approaches and reduceand eliminate human exposures and health impacts.

Industrial Hygienists are scientists, engineers, and public healthprofessionals committed to protecting the health people in theworkplace and the community.

4.0 CONCLUSION

The work environment and process predispose workers to a number of accidental occurrences, injuries and even death. This makes it imperative for conscious efforts to be made to protect and promote the health of workers. This module attempted an overview of occupational health and safety. Efforts were made to introduce the concept, its aims and objectives, key principles and some terms associated with the concept.

5.0 SUMMARY

- Health is widely defined as a state of complete physical, mental and social well-being and not merely the absence of disease and infirmity.
- There are three major dimensions of health including physical, mental and social health dimensions
- Occupational health is a multidisciplinary activity aimed at the protection and promotion of the health of workers by preventing and controlling occupational diseases and accidents and by eliminating occupational conditions and factors hazardous to health and safety at work. It also connotes development and promotion of healthy and safe work, work environments and work conditions.
- The overall objective of occupational health is the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations;
- The basic concepts in occupational health include: the worker, working tool, working process and the work environment.
- These concepts interact in a complex manner to significantly influence the health of workers.

6.0 TUTORED-MARKED ASSIGNMENT

1. What is Occupational Health?
2. State at five aims and objectives of occupational health
3. State the general rationale for occupational health
4. Mention at least seven key principles of occupational health

Answer to Tutorial Questions
Occupational Health
Occupational health has been defined as the promotion and maintenance of the highest degree of physical, mental social well- being of workers in all occupation. It is a multidisciplinary activity aimed at the protection and promotion of the health of workers by preventing and controlling occupational diseases and accidents and by eliminating occupational conditions and factors hazardous to health and safety at work.

Aims and Objectives of Occupational Health

1. Promoting and maintaining of the highest degree of physical, mental and social well-being of workers in all occupations;
2. Preventing adverse effects on health caused by their working conditions of workers;
3. Protecting of workers in their employment from risks resulting from factors adverse to health;
4. Placing in an occupational environment adapted to their physical and mental health needs;
5. Adapting work to man
6. Preventing accident in the work place
7. Defending and advancing workers' health

General Rationale for Occupational Health

The rationale for occupational health is to make the work environment safe and healthy with a view to improving workers' output, reducing cost for treatment and compensation as well as improving workers health.

Key Principles of Occupational Health

1. Every worker has a right to life and this right must be respected
2. Occupational safety and health policies must be established at the governmental ad industry levels
3. A national system for occupational safety and health must be established
4. A national programme on occupational safety and health must be formulated.
5. Stakeholders must be involved in policy formulation
6. Occupational health programmes must aim at both prevention and protection
7. Continuous improvement of occupational safety and health must be promoted

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MODULE 2 DEVELOPMENT OF OCCUPATIONAL HEALTH: A HISTORICAL PERSPECTIVE

CONTENTS

1.0 INTRODUCTION

This module focuses on historical development of occupational health. The history of occupational health is traced from ancient times in the module. Some developed countries of the world, notably United Kingdom and USA played important roles in the historical development of occupational health. As a result, the module briefly describes occupational health development in these countries. Industrial Revolution started in the United Kingdom, this makes the country to occupy central place in the historical development of occupational health. An attempt was also made to give an overview of historical development of occupational health in developing countries and wrapped with an overview of historical development of occupational health in Nigeria.

2.0 OBJECTIVES

At the end of this module, you should be able to narrate:

- Historical development of occupational health in the United Kingdom
- Historical development of occupational health in USA
- Historical development of occupational health in Nigeria

3.0 Main Content

3.1 Historical Development of Occupational Health in Ancient Times

The work place is a potentially hazardous environment wheremillions of employees pass at least one-third of their life time. Thisfact has been recognized for a long time, although developed veryslowly until 1900.There has been an awareness of industrial hygiene since antiquity.The environment and its relation to worker health was recognized asearly as the fourth century BC when Hippocrates noted lead toxicityin the mining industry. In the first century AD, Pliny the Elder, aRoman scholar, perceived health risks to those working with zincand sulfur. He devised a face mask made from an animal bladder toprotect workers from exposure to dust and lead fumes. In the Second Century AD, the Greek physician, Galen, accuratelydescribed the pathology of lead poisoning and also recognized thehazardous exposures of copper miners to acid mists.In the middle Ages, guilds worked at assisting sick workers and theirfamilies. In 1556, the German scholar, Agricola, advanced thescience of industrial hygiene even further when, in his book De ReMetallica, he described the diseases of miners and prescribedpreventive measures. The book included suggestions for mineventilation and worker protection, discussed mining accidents, anddescribed diseases associated with mining occupations such assilicosis.

Industrial hygiene gained further respectability in 1700 whenBernardo Ramazzini, known as the "father of industrial medicine,"published in Italy the first comprehensive book on industrialmedicine, De MorbisArtificumDiatriba (The Diseases of Workmen).The book contained accurate descriptions of the occupationaldiseases of most of the workers of his time. Ramazzini greatlyaffected the future of industrial hygiene because he asserted thatoccupational diseases should be studied in the work environmentrather than in hospital wards.Industrial hygiene received another major boost in 1743 when UlrichEllenborg published a pamphlet on occupational diseases andinjuries among gold miners. Ellenborg also wrote about the toxicityof carbon monoxide, mercury, lead, and nitric acid.

However, concrete approach to the control of occupational diseases became valid in most countries after the twentieth century. Emphasis was then given to the control of working hazards, and multidisciplinary approach to such effective measures in which at least triparty: the employer, the employee, and the competent authority are together participating in the problem solution. Much improvement in the workers’ health protection has been made in developed countries in the field of industrial hygiene and safety, and occupational medicine. There is still a long distance ahead for developing countries like Nigeria.

3.2 Historical Development of Occupational Health in England

England is at the centre of occupational health as the Industrial Revolution began here. TheIndustrial Revolution marked a turning point in occupational health history as the revolution led to industrialization which in turn necessitated organized employer-employee relationship. The invention of the seed drill by JethroTull and the use of coke to melt smelt iron by Abraham Darby led to the Industrial Revolution during the early part of the 18^{th} Century (Asogwa, 2007). This major break in the industrial process necessitated the employment of women and children in factories as more workforce was needed. These women and children had to work long hours under very harsh and unhealthy conditions. This harsh condition of work led to the call for serious reforms. This advocacy was championed by medical practitioners as well as lay people. Prominent among medical practitioners that led this advocacy especially through the pen are Dr. Charles Turner Thachrah (1795 - 1833) and Lord Anthony Ashley Cooper (1801 - 1885). The numerous contribution of Dr. Thachrahin fighting the harsh conditions that industrial workers were subjected to earned him 'Father of British Industrial Medicine' (Asogwa, 2007).

In the 18th century, Percival Pott, as a result of his findings on the insidious effects of soot on chimney sweepers, was a major force in getting the British Parliament to pass the Chimney- Sweepers Act of 1788. The passage of the English Factory Acts beginning in 1833 marked the first effective legislative acts in the field of industrial safety. The Acts, however, were intended to provide compensation for accidents rather than to control theircauses. Later, various other European nations developed workers' compensation acts, which stimulated the adoption of increased factory safety precautions and the establishment of medical services within industrial plants.

A member of the British Parliament by name, Lord Cooper advanced the course of industrial workers by pushing through legislation which reduced the hours of work and improved the conditions of work of women and young persons employed in mines, factories and other workplaces. The medical profession led trailed the blaze in advancing occupational health in the United Kingdom. The first medical involvement in the industry took effect in 1898 when Sir Thomas Morrison Leggee (1863 - 1932) was appointed the first British Medical Factory Inspector what has become

Occupational Health Consultant in modern times. Dr. Leggee introduced the idea of notifying occupational diseases especially lead poison. Dr. Leggee also emphasized prevention as the most effective strategy to combating occupational disease. His views on occupational disease prevention have been transformed to what is now known as Legge's Aphorisms.as follows:

1. "Unless and until the employer has done everything and everything means a good deal - the workman can do next to nothing to protect himself; although he is naturally willing enough to do his share".
2. "If you can bring an influence to bear external to the workman - that is one over which he has no contract - you will be successful and if you cannot or do not, you will never be wholly successful".
3. "Practically, all industrial lead poisoning is due to the inhalation of dust and fume, and if you stop their inhalation you stop the poisoning".
4. "All workmen should be told something of the danger of the material with which they come into contacts, and not be left to find it out for themselves - sometimes at the cost of their lives".

A landmark development in occupational health was the enactment of the Factories Act of 1839 which among other things regulated child labour in the industries. Another landmark legislation breakthrough came in 1884 when an Act that mandated appointment of certifying surgeon was made. This surgeon must certify that anyone to be employed to work in the industries must undergo fitness assessment and must be certified to be fit.

3.3 Historical Development of Occupational Health in USA

The Industrial Revolution in Englandalso features prominently in the historical development of occupational health in the United States of America. Just as was the case in England, poor working conditions as high level of exploitation of the working force by their employers led to public concerns and advocacy for legislations. The high level of industrialization in the United States prompted an alarming workforce immigration projected at 16.5 million immigrant workers within 50 years –1890-1914.

The rapid industrialization witnessed during the period saw workers working for as high as 12-14 hours shifts throughout the seven calendar days. Again, these workers worked under harsh and unhealthy environments characterized by pollutants and hazards like dust, physical hazards, smoke, heat, cold and dangerous fumes. This poor working conditions led to low life span among the workers as workers were dying before clocking sixty years from occupational based diseases.Unfortunately, employers vehemently opposed attributing early death of the factory workers to their working conditions but to their home conditions and their personal habits (Lee, 1978; Allender and Spradley,1996).

Therefore, to improve on this condition, research efforts were employed to empirically prove that poor working conditions at the factories were responsible for high level of occupational diseases and early deaths among the workers.BernadinoRamazzini, an Italian Physician known as the "father of occupational medicine", pioneeredempirical studies on occupational health. Based on the outcome of his research, he published a treatise titled Discourse on the Disease of Workers."He argued that a worker's health status is a function of the working condition and environment in which he/she works.

In the early 20th century in the U.S., Dr. Alice Hamilton led efforts to improve industrial hygiene. She observed industrial conditions first hand and startled mine owners, factory managers, and state officials with evidence that there was a correlation between worker illness and exposure to toxins. She also presented definitive proposals for eliminating unhealthful working conditions. At about the same time, U.S. federal and state agencies began investigating health conditions in industry. In 1908, public awareness of occupationally related diseases stimulated the passage of compensation acts for certain civil employees. States passed the first workers' compensation laws in 1911. And in 1913, the New York Department of Labour and the Ohio Department of Health established the first state industrial hygiene programs. All states enacted such legislation by 1948.

In most states, there is some compensation coverage for workers contracting occupational diseases. The U.S. Congress has passed three landmark pieces of legislation related to safeguarding workers' health: (1) the Metal and Non metallic Mines Safety Act of 1966, (2) the Federal Coal Mine Safety and Health Act of 1969, and (3) the Occupational Safety and Health Act of 1970 (OSH Act). Today, nearly every employer is required to implement the elements of an industrial hygiene and safety, occupational health, or hazard communication program and to be responsive to the Occupational Safety and Health Administration (OSHA) and its regulations.

Under the OSH Act, OSHA develops and sets mandatory occupational safety and health requirements applicable to the more than 6 million workplaces in the U.S. OSHA relies on, among many others, industrial hygienists to evaluate jobs for potential health hazards. Developing and setting mandatory occupational safety and health standards involves determining the extent of employee exposure to hazards and deciding what is needed to control these hazards to protect workers. Industrial hygienists are trained to anticipate, recognize, evaluate, and recommend controls for environmental and physical hazards that can affect the health and well-being of workers.

More than 40 percent of the OSHA compliance officers who inspect America's workplaces are industrial hygienists. Industrial hygienists also play a major role in developing and issuing OSHA standards to protect workers from health hazards associated with toxic chemicals, biological hazards, and harmful physical agents. They also provide technical assistance and support to the agency's national and regional offices. OSHA also employs industrial hygienists who assist in setting up field enforcement procedures, and who issue technical interpretations of OSHA regulations and standards.Industrial hygienists analyze, identify, and measure workplacehazards or stresses that can cause sickness, impaired health, orsignificant discomfort in workers through chemical, physical,ergonomic, or biological exposures. Two roles of the OSHAindustrial hygienist are to spot those conditions and help eliminate orcontrol them through appropriate measures.

3.4 Historical Development of Occupational Health in Developing Countries

Just as is the case in England and USA, occupational health evolved in developing countries because of industrialization. The occupational health in most developing countries was as a result of industrialization. Prior to colonization, most, if not all, the developing countries relied heavily on peasant farming for survival. With colonization, industries and occupational health arrangements in the empire countries were introduced in the colonies. Asogwa (2007) noted that even after independence developing countries model their occupational health legislations after that of their colonialists of which some of them still maintain economic relationships. Services of nurses, doctors and other health professionals were relied upon in industries for the health needs of the workers in industries.

In the historical development of occupational health in developing countries, occupational health services were mainly response based and curative in nature. Asogwa (2007) noted that general medicine was practiced by the occupational health team led by the general practitioner doctor instead of occupational medicine. It is also important to mention that occupational health services at this stage were a function of the size of the industries providing them. Small and medium sized industries engaged the service of medical doctors who operate from their hospitals were workers go to when ill. Apart from the worker, a single wife and not more than four children that are not upto eighteen years of age are covered. The employer pays the doctor based on the number of people that reported to him for treatment on a specified timely basis. On the other hand, larger firms have doctors who are resident in the industry as occupational doctors and health professionals.

3.5 Historical Development of Occupational Health in Nigeria

Until industrialization entered Nigeria, there was no organized platform for engagement of people as workers who are entitled to wages. Although people involved in peasant farming and some forms of labours were provided, there was no organized industrial setting in the sense of the world, industry or factory. However, the arrival of the British colonialists and the establishment of industries like the coal industries led to organized work arrangement thus requiring occupational health services. This marked the beginning of occupational health in Nigeria.

According to Nwachukwu (2000), the research efforts and recommendations of Dr. W.S. Ladel contributed significantly to the rise of occupational health in Nigeria. Ladel made useful recommendations regarding the proper designing and construction of factory buildings, commensurate with stipulated health standards. The contributions of another researcher, Dr. Ola Ojikutu also advanced the development of industrial health in Nigeria.

However, historical account shows that the first occupational health services in Nigeria was introduced by the Medical Examination Board of Liverpool Inferminary in 1789. This health service was designed to cater for the health needs of British slave traders. With the abolition of transatlantic slave trade, the Royal Niger Company of Britain increased its exploration and trading activities in Nigeria. This company had occupational health service for its workers. Again, during the colonial rule, many of the British soldiers and administrators suffered and died of malaria. This prompted the establishment of health and welfare services for these personnel thereby advancing occupational health development in the country. It is equally important to mention that with the outbreak of the Second World War, the occupational health service largely provided by the medical corps focused on fighting soldiers. This necessitated the establishment of public health service by the colonial administrators.

After the Second World War, Nigeria experienced increased establishment of industries of which the construction companies and coal mining factories were leading ones. Rise in the number of industrial activities led to increased number of labourers. But these workers were subjected to working under harsh and unconducive conditions. Prevention of hazards especially in mining industries like coal was not given due attention. This led to the death of many workers in the coal industry. This stimulated agitations on the poor working conditions of coal miners. This and other cases led to legislations on occupational health and protection of workers from occupational hazards.

The earliest practices that can be regarded as occupational health services in Nigeria were carried out by British Companies like UAC, John Holt. This was followed by establishment of some occupational health services by Nigerian governments in the Railway Corporation and Coal Mines. Such services included pre-employment and periodic medical examination, treatment of minor illnesses and accidents. In some cases, general practitioners were hired on part time basis, especially in urban centres to take care of the sick injured workers. The increased industrialization and its impact on health, safety and welfare of workers lead to the creation of occupational health unit in the Federal Ministry of Health and the Institute of Occupational Health in Oyo State Ministry of Health. These agencies organized courses for managers, safety officers, medical officers, occupational hygienists, and other personnel involved with the protection, maintenance and promotion of health and welfare of workers in Nigeria.

Legislation regarding industrial health in Nigeria predated independence as it began with the colonial administrators (Nwachukwu, 2000). The provisions of the Factories Act of Nigeria therefore were near representations of the provisions of the Factories Act of Britain. Unfortunately, little has been done to evolve industrial legislations that are entirely reflective of the Nigerian peculiar situation and condition although amendments have been done to the Act since enactment.

4.0 CONCLUSION

The historical development of occupational health is largely traceable to the Industrial Revolution in England. This led to increased engagement of people as workers in poor sanitary conditions. It was the agitation that followed the poor working conditions during this period that led to the development of occupational health as regards research and practice.

5.0 SUMMARY

- Occupational health started with man however, as a discipline and filed, it is traceable to Hippocrates who in the Fourth Century BC recognized lead toxicity in the mining industry
- In the first century AD, Pliny the Elder, a Roman scholar, perceived health risks to those working with zinc and sulfur. He devised a face mask made from an animal bladder to protect workers from exposure to dust and lead fumes. In the Second Century AD, the Greek physician, Galen, accurately described the pathology of lead poisoning and also recognized the hazardous exposures of copper miners to acid mists.
- Agricola, a German scholar in 1556 wrote a book, De ReMetallica, which contributed immensely to the development of occupational health.
- Occupational health gained a boost in 1700 when Bernardo Ramazzini, known as the "father of industrial medicine," published in Italy the first comprehensive book on industrial medicine, titled, De Morbis Artificum Diatriba (The Diseases of Workmen).The book contained accurate descriptions of the occupational diseases of most of the workers of his time. Ramazzini advocated that occupational diseases be studied in the work environment instead of in hospital wards. This assertion greatly advanced occupational health as field of study.
- The Industrial Revolution marked a turning point in occupational health history as the revolution led to industrialization which in turn necessitated organized employer-employee relationship.
- Harsh working conditions of workers during the Industrial Revolution led to agitations that culminated in legislations regarding the protection of the health status of workers in England.
- Just as in England, poor working conditions in USA prompted legislations for protecting the health of workers
- Industrialization equally triggered occupational health and its development in developing countries including Nigeria.
- The establishment of factories, notably the coal factory in Nigeria marked the beginning of occupational health in Nigeria.

6.0 TUTOR-MARKED ASSIGNMENT

State at least two striking events in the historical development of occupational health in the understated period or location

1. Ancient times
2. England
3. USA
4. Nigeria

Answer to Assignment

Two Notable Events in Historical Development of Occupational Health in Ancient Times

- Hippocrates in the Fourth BC identified lead poisoning in the mining industry and made useful recommendations on the need for protecting the health of miners in particular and workers in general
- In the First Century AD, Pliny the Elder, a Roman scholar, devised a face mask from animal skin to protect industrial workers from exposures to lead and fumes
- In 1556, Agricola, a German scholar wrote extensively on occupational diseases and how best to prevent them
- In 1700, Bernardo Ramazzini, known as the "father of industrial medicine," published a book titled “Diseases of Workmen.” In the book he highlighted various health challenges against workers and made useful suggestions on preventive measures.

Two Notable Events in Historical Development of Occupational Health in England

- Industrial Revolution and poor working condition inspired people to call for legislations to protect the health of workers
- In the 18th Century, Percival Pott, based on research findings, on the harmful effects of soot on chimney sweepers, compelled, through advocacy, that the British Parliament to pass the Chimney- Sweepers Act of 1788.
- The passage of the English Factory Acts beginning in 1833 marked the first effective legislative acts in the field of industrial safety. The Acts, however, were intended to provide compensation for accidents rather than to control their causes

Two Notable Events in Historical Development of Occupational Health in USA

- Industrial Revolution also marked the development of occupational health in the US

- In the early 20th century in the U.S., Dr. Alice Hamilton led efforts to improve industrial hygiene. She observed industrial conditions first hand and startled mine owners, factory managers, and state officials with evidence that there was a correlation between worker illness and exposure to toxins.
- At about the same time, U.S. federal and state agencies began investigating health conditions in industry.
- In 1908, public awareness of occupationally related diseases stimulated the passage of compensation acts for certain civil employees. States passed the first workers' compensation laws in 1911.
- 1913, the New York Department of Labour and the Ohio Department of Health established the first state industrial hygiene programmes. All states enacted such legislation by 1948.
- In most states, there is some compensation coverage for workers contracting occupational diseases. The U.S. Congress passed three landmark pieces of legislation related to safeguarding workers' health: (1) the Metal and Non metallic Mines Safety Act of 1966, (2) the Federal Coal Mine Safety and Health Act of 1969, and (3) the Occupational Safety and Health Act of 1970 (OSH Act).

Two Notable Events in Historical Development of Occupational Health in USA

- Industrialization brought about occupational health and its development in Nigeria especially after the Second World War.
- Historical account shows that the first occupational health services in Nigeria was introduced by the Medical Examination Board of Liverpool Inferminary in 1789 although this health service was provided for British slave traders.
- Colonial rule saw some Britons holding administrative position in the colony. Health services were provided for these administrators in form of occupational health
- Occupational health services were also provided for government workers like the Railway Corporation and the Coal Mine Industry

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MODULE 3 IDENTIFICATION OF OCCUPATIONAL HAZARDS

CONTENTS

1.0 INTRODUCTION

This module focuses on hazards and identification of occupational health and safety hazards. The working environment is full of hazards that must be consciously controlled in order to reduce the risk of their manifestations. On their own, these hazards are not harmful but become dangerous when they are not properly controlled and therefore allowed to manifest. The module also covers purpose of identification of these hazards, benefits of identifying them and the classifications of these hazards.

2.0 OBJECTIVES

At the end of this module, you should be able to:

- Define what an hazard is
- State at least five purposes of identification of occupational hazards
- State five ways of occupational hazards identification
- Mention classifications of hazards
- Briefly explain each classification of occupational hazards citing examples.

3.0 MAIN CONTENT

3.1 Meaning of Hazard and Occupational Hazard

A hazard is something which is known to cause harm, that is, a source of danger to health. Risk is the likelihood or probability of the hazard occurring and the magnitude of the resulting effects. An occupational hazard is thus any occupational factor or situation that can cause injury, disease or death. Occupational hazards on their own are not harmful but can become harmful if the risk of their manifestations are not reduced to the barest minimum. For instance, the machineries in an industrial setting are not harmful if they are used as they should be used. When there is any error in their operation, this error can result in accident, injury or even death, depending on its severity. It is therefore important to reduce occupational hazard risks to the barest minimum.

In order to reduce the risk of occupational health hazards, these hazards must first be identified and the extent of their potential harm defined. Identification of occupational health and safety hazards has oftencome from observations of adverse health effect among workers.

Purpose of identification of Occupational Hazards

The purposes of identifying occupational hazards include:

1. Obtaining information on occupational health stresses
2. Collecting information on working conditions
3. Collecting information on work processes and products
4. Obtaining the threshold limit values for substances
5. Collecting information on the effects of exposure on human
6. Collecting data on exposure levels by conducting elementarymeasurements
7. Determining where problem or potential problem area exist

3.2 Importance of Identification of Occupational Hazards

Not all exposures to occupational stresses are hazardous and insome instances, occupational exposure limits are never reached. In this case, these areas can be eliminated from extensive evaluation thus reducing the total evaluation and monitoring process. Identification lays the foundation for evaluation of hazards as identification process involves collection of data. Although it is not necessary to carry outidentification in an area every time one wishes to quantify workers'exposure in an area as that would amount to redesigning the wheel.Identification saves time, effort and eventually money.

Identification of health and safety problems includes the following:

1. Observe workplace
2. Investigate complaints from workers
3. Examine accident and near-miss records
4. Examine sickness figures
5. Use simple surveys to ask co-workers about their healthand safety concerns;
6. Use check-lists to inspect your workplace;
7. Learn the results of inspections that are done by theemployer, the union or anyone else;
8. Read reports or other information about the workplace

3.3 Classification of Occupational Hazards

The various hazards which give rise to occupational injuries,diseases, disabilities or death through work may have been classified by Takele and Mengesha (2006) and Ogundele (2017) as:

1. Physical Hazards
2. Mechanical Hazards
3. Chemical Hazards
4. Biological Hazards
5. Ergonomic Hazards
6. Psychosocial Hazards

3.3.1 Physical Hazards

Physical hazards, which can adversely affect health, include noise,vibration, ionizing and non-ionizing radiation, heat and otherunhealthy microclimatic conditions. Between 10 and 30% of theworkforce in industrialized countries and up to 80% in developingand newly industrialized countries are exposed to a variety of thesepotential hazards.Physical hazard has possible cumulative or immediate effects on thehealth of employees. Therefore, employers and inspectors shouldbe alert to protect the workers from adverse physical hazards. Typical examples of physical hazards are briefly discussed below:

- **Extreme Temperature**

The work environment is either comfortable or extremely cold or hotand uncomfortable. The common physical hazard in most industriesis heat. Extreme hot temperature prevails on those who are workingin foundries or in those industries where they use open fire forenergy. Examples of these include soap factories in large industriesand in the informal sectors that use extreme heat to mold iron orprocess other materials.

Effects of hot temperature in work place include:

1. **Heat Stress**

   Heat stress is a common problem in workplace because people ingeneral function only in a very narrow temperature range as seenfrom core temperature measured deep inside the body. Fluctuation in core temperature about 2^0 C below or 3^0C above the normal core temperature of 37.6^0C impairs performance markedly and ahealth hazard exists. When this happens the body attempt tocounteract by:

   - Increasing the heart rate
   - The capillaries in the skin dilate to bring more blood to thesurface so that the rate of cooling is increased.
   - Sweating to cool the body

2. **Heat stroke**

   Heat stroke is caused when the body temperature rises rapidly in aworker who is exposed to a work environment in which the body isunable to cool itself sufficiently. Predisposing factors for heat strokeis excessive physical exertion in extreme heat condition. Themethod of control is therefore, to reduce the temperature of thesurrounding or to increase the ability of the body to cool itself.

3. **Heat Cramp**

   Heat cramp may result from exposure to high temperature for arelatively long time particularly if accompanied by heavy exertion orsweating with excessive loss of salt and moisture from the body.

4. **Heat Exhaustion**

   This also results from physical exertion in hot environment. Signs ofthe problem include:

   - Mildly elevated temperature
   - Weak pulse
   - Dizziness
   - Profuse sweating
   - Cool, moist skin, heat rash

5. Cold Stress

Cold stress could mainly be defined as the effect of the externalworking environment (Very low temperatures i.e. less than 6^0C)and the resultant inability of the body to maintain a constant internalbody temperature. High airflow is a critical factor here, as it willincrease cold stress effects considerably. This is commonly referredto as the wind chill factor.

Special condition that occur in cold weather

1. Trench Foot

An injury which results from long exposure of the feet tocontinued wet condition at freezing temperature withlittle movement causes changes in the circulation of blood in thefeet.Trench foot can result in loss of toes or part of the feet. To treat trench foot, keep foot dry and warm and engage in exercise for goodcirculation.

2. Immersion foot

Immersion of foot in water that is below 10^0 C, for a prolongedtime, usually in excess of 24 hours.

3. Frostbite

This is injury of body tissuesdue to exposure to intense cold.Body parts most easily frostbitten include cheeks, nose, ears, chin forehead, wrists,hands and feet.

Prevention of Frostbite

Frostbite can be prevented by:

- Wearing the proper amount warm, loose, dryclothing.
- Massaging the face, hand, and feet periodically topromote good circulation.
- Troops travelling in cold weather by, particularly inthe rear of trucks should be allowed to dismount andexercise periodically to restore circulation.
- If clothing become wet, it should be dried or changeat once.

❖ **Vibration Motion Conditions**

Vibration causes vascular disorders of the arms and bony changesin the small bones of the wrist. Vascular changes can be detected byX-ray examination of the wrist. The most common findings israrefaction of the lunate bone.

❖ **Atmospheric Pressure (high and low)**

Exposure to increased atmospheric pressure (under water) leads toaseptic bone necrosis around the knee, hip and shoulder that can bedetected by X-ray examination

❖ **Non-Ionizing and Ionizing Radiation**

Radiation having a wide range of energies forms theelectromagnetic spectrum.

The spectrumhas two major divisions: non-ionizing and ionizing radiation.Radiation that has enough energy to move atoms in a moleculearound or cause them to vibrate, but not enough to removeelectrons, is referred to as "non-ionizing radiation." Examples of thiskind of radiation are sound waves, visible light, and microwaves.

Radiation that falls within the ionizing radiation" range has enoughenergy to remove tightly bound electrons from atoms, thus creatingions. This is the type of radiation that people usually think of as'radiation.' We take advantage of its properties to generate electricpower, to kill cancer cells, and in many manufacturing processes.

Non-ionizing Radiation

We take advantage of the properties of non-ionizing radiation for common tasks:

- microwave radiation-- telecommunications and heating food
- infrared radiation --infrared lamps to keep food warm in restaurants
- radio waves-- broadcasting

Non-ionizing radiation ranges from extremely low frequency radiation, shown on the far left through the audible, microwave, and visible portions of the spectrum into the ultraviolet range. Extremely low-frequency radiation has very long wave lengths (on the order of a million meters or more) and frequencies in the range of 100 Hertz or cycles per second or less. Radio frequencies have wave lengths of between 1 and 100 meters and frequencies in the range of 1 million to 100 million Hertz. Microwaves that we use to heat food have wavelengths that are about 1 hundredth of a meter long and have frequencies of about 2.5 billion Hertz.

Ionizing Radiation

Ionizing radiation has many practical uses, but it is also dangerousto human health. It radiation is either particle radiation or electromagneticradiation in which an individual particle/photon carries enoughenergy to ionize an atom or molecule by completely removing anelectron from its orbit. If the individual particles do not carry thisamount of energy, it is essentially impossible for even a large floodof particles to cause ionization. These ionizations, if enough occur,can be very destructive to living tissue, and can cause DNA damageand mutations.

Examples of particle radiation that are ionizing maybe energetic electrons, neutrons, atomic ions or photons.Electromagnetic radiation can cause ionization if the energy perphoton, or frequency, is high enough, and thus the wavelength isshort enough. The amount of energy required varies betweenmolecules being ionized. X-rays, and gamma rays will ionize almostany molecule or atom. Far ultraviolet, near ultraviolet and visible lightare ionizing to some molecules; microwaves and radio waves are
Non-ionizing radiation.However, visible light is so common that molecules that are ionizedby it will often react nearly spontaneously unless protected bymaterials that block the visible spectrum. Examples includephotographic film and some molecules involved in photosynthesis.

Alpha radiation consists of helium-4 nuclei and is readily stopped bya sheet of paper. Beta radiation, consisting of electrons, is halted byan aluminium plate. Gamma radiation is eventually absorbed as itpenetrates a dense material (see illustrated diagram above).Ionizing radiation is produced by radioactive decay, nuclear fissionand nuclear fusion, by extremely hot objects (the hot sun, e.g.,produces ultraviolet), and by particle accelerators that may produce,e.g., fast electrons or protons or synchrotronradiation.

In order for radiation to be ionizing, the particles must both have ahigh enough energy and interact with electrons. Photons interactstrongly with charged particles, so photons of sufficiently highenergy are ionizing. The energy at which this begins to happen is inthe ultraviolet region; sunburn is one of the effects of this ionization.Charged particles such as electrons, positrons, and alpha particlesalso interact strongly with electrons. Neutrons, on the other hand, donot interact strongly with electrons, and so they cannot directlyionize atoms. They can interact with atomic nuclei, depending on thenucleus and their velocity, these reactions happen with fast neutronsand slow neutrons, depending on the situation. Neutron radiationoften produces radioactive nuclei, which produce ionizing radiationwhen they decay.

The negatively charged electrons and positively charged ionscreated by ionizing radiation may cause damage in living tissue. Ifthe dose is sufficient, the effect may be seen almost immediately, inthe form of radiation poisoning. Lower doses may cause cancer orother long-term problems. The effect of the very low dosesencountered in normal circumstances (from both natural and artificialsources, like cosmic rays, medical X-rays and nuclear power plants)is a subject of current debate.

Radioactive materials usually release alpha particles which are thenuclei of helium, beta particles, which are quickly moving electronsor positrons, or gamma rays. Alpha and beta rays can often beshielded by a piece of paper or a sheet of aluminium, respectively.They cause most damage when they are emitted inside the humanbody. Gamma rays are less ionizing than either alpha or beta rays, but protection against them requires thicker shielding. They producedamage similar to that caused by X-rays such as burns, and cancerthrough mutations. Human biology resists germline mutation byeither correcting the changes in the DNA or inducing apoptosis inthe mutated cell.

Non-ionizing radiation is thought to be essentially harmless belowthe levels that cause heating. Ionizing radiation is dangerous indirect exposure, although the degree of danger is a subject ofdebate. Humans and animals can also be exposed to ionizingradiation internally: if radioactive isotopes are present in theenvironment, they may be taken into the body. For example, radioactive iodine is treated as normal iodine by the body and usedby the thyroid; its accumulation there often leads to thyroid cancer.Some radioactive elements also bioaccumulate.

Uses of ionizing radiation

Ionizing radiation has many uses. An X-ray is ionizing radiation, andionizing radiation can be used in medicine to kill cancerous cells.However, although ionizing radiation has many uses, the overuse ofit can be hazardous to human health. Shop assistants in shoe shopsused to use an X-ray machine to check a child's shoe size, whichwould be a big treat for the child. But when it was discovered thationizing radiation was dangerous these machines were promptly removed.

Effects of ionizing radiation on human health

Natural radiation

Natural background radiation comes from four primary sources:

- Cosmic radiation,
- Solar radiation,
- External terrestrial sources, and
- Radon.

Cosmic radiation

The earth and all living things on it, are constantly bombarded byradiation from outside our solar system of positively charged ionsfrom protons to iron nuclei. The energy of this radiation can farexceed energies that humans can create even in the largest particleaccelerators. This radiation interacts in the atmosphere to createsecondary radiation that rains down, including x-rays, muons,protons, alpha particles, pions, electrons, and neutrons.The dose from cosmic radiation is largely from muons, neutrons, andelectrons. The dose rate from cosmic radiation varies in differentparts of the world based largely on the geomagnetic field, altitude, and solar cycle. The dose rate from cosmic radiation on airplanes isso high that, according to the United Nations UNSCEAR 2000Report, airline workers receive more dose on average than anyother worker, including nuclear power plant workers.

Solar radiation

While most solar radiation is electro-magnetic radiation, the sun alsoproduces particle radiation, solar particles, which vary with the solarcycle. They are mostly protons; these are relatively low in energy(10-100 keV). The average composition is similar to that of the Sunitself. This represents significantly lower energy particles than come from cosmic rays. Solar particles vary widely in their intensity andspectrum, increasing in strength after some solar events such assolar flares. Again, an increase in the intensity of solar cosmic raysis often followed by a decrease in the galactic cosmic rays, called aForbush decrease after their discoverer, the physicist Scott Forbush.These decreases are due to the solar wind which carries the sun'smagnetic field out further to shield the earth more thoroughly fromcosmic radiation.

External terrestrial sources

Most material on earth contains some radioactive atoms, if in smallquantities. But most of terrestrial non-radon-dose one receives fromthese sources is from gamma-ray emitters in the walls and floorswhen inside the house or rocks and soil when outside. The majorradionuclides of concern for terrestrial radiation are potassium,uranium and thorium. Each of these sources has been decreasing inactivity since the birth of the Earth so that our present dose frompotassium-40 is about ½ what it would have been at the dawn of lifeon Earth.

Radon

Radon-222 is produced by the decay of Radium-226 which ispresent wherever uranium is. Since Radon is a gas, it seeps out ofuranium-containing soils found across most of the world and mayconcentrate in well-sealed homes. It is often the single largestcontributor to an individual's background radiation dose and iscertainly the most variable from location to location. Radon gas isthe second largest cause of lung cancer in America, after smoking.

Artificial/Human-made radiation sources

Natural and artificial radiation sources are identical in their natureand their effect. Above the background level of radiation exposure,the U.S. Nuclear Regulatory Commission (NRC) requires that itslicensees limit human-made radiation exposure to individualmembers of the public to 100 mrem (1 mSv) per year, and limitoccupational radiation exposure to adults working with radioactivematerial to 5,000 mrem (50 mSv) per year.

One importantsource of natural radiation is radon gas, which seeps continuouslyfrom bedrock but can, because of its high density, accumulate inpoorly ventilated houses.The background rate varies considerably with location, being as lowas 1.5 mSv/a in some areas and over 100 mSv/a in others. Peoplein some areas of Ramsar, a city in northern Iran, receive an annualradiation absorbed dose from background radiation that is up to 260mSv/a. Despite having lived for many generations in these highbackground areas, inhabitants of Ramsar show no significantcytogenetic differences compared to people in normal backgroundareas; this has led to the suggestion that the body can sustain muchhigher steady levels of radiation than sudden bursts.

Some human-made radiation sources affect the body through directradiation, while others take the form of radioactive contaminationand irradiate the body from the inside.By far, the most significant source of human-made radiationexposure to the general public is from medical procedures, such asdiagnostic X-rays, nuclear medicine, and radiation therapy. These are rarely released into the environment.In addition, members of the public are exposed to radiation fromconsumer products, such as tobacco (polonium-210), buildingmaterials, combustible fuels (gas, coal, etc.), ophthalmic glass,televisions, luminous watches and dials (tritium), airport X-raysystems, smoke detectors (americium), road construction materials,electron tubes, fluorescent lamp starters, lantern mantles (thorium),etc.

Of lesser magnitude, members of the public are exposed to radiationfrom the nuclear fuel cycle, which includes the entire sequence frommining and milling of uranium to the disposal of the spent fuel. Theeffects of such exposure have not been reliably measured.Estimates of exposure are low enough that proponents of nuclearpower liken them to the mutagenic power of wearing trousers for twoextra minutes per year (because heat causes mutation). Opponentsuse a cancer per dose model to prove that such activities causeseveral hundred cases of cancer per year.

In a nuclear war, gamma rays from fallout of nuclear weapons wouldprobably cause the largest number of casualties. Immediatelydownwind of targets, doses would exceed 300 Gy per hour. As areference, 4.5 Gy (around 15,000 times the average annualbackground rate) is fatal to half of a normal population.Occupationally exposed individuals are exposed according to thesources with which they work. The radiation exposure of theseindividuals is carefully monitored with the use of pocket-pen-sizedinstruments called dosimeters.Some of the radionuclides of concern include cobalt-60, caesium-137, americium-241 and iodine-131. Examples of industries whereoccupational exposure is a concern include:

- Airline crew (the most exposed population)
- Fuel cycle
- Industrial Radiography
- Radiology Departments (Medical)
- Radiation Oncology Departments
- Nuclear power plant
- Nuclear medicine Departments
- National (government) and university Research Laboratories

The effects of ionizing radiation on animals

The biological effects of radiation are thought of in terms of theireffect on living cells. For low levels of radiation exposure, thebiological effects are so small they may not be detected inepidemiological studies. The body repairs many types of radiation and chemical damage. Biological effects of radiation on living cellsmay result in a variety of outcomes, including:

1. Cells experience DNA damage and are able to detect andrepair the damage.
2. Cells experience DNA damage and are unable to repair thedamage. These cells may go through the process ofprogrammed cell death, or apoptosis, thus eliminating thepotential genetic damage from the larger tissue.
3. Cells experience a nonlethal DNA mutation that is passedon to subsequent cell divisions. This mutation may contribute to the formation of a cancer.

Other observations at the tissue level are more complicated. Theseinclude:

1. In some cases, a small radiation dose reduces the impact ofa subsequent, larger radiation dose. This has been termedan 'adaptive response' and is related to hypotheticalmechanisms of hormesis.

2. Cells that are not 'hit' by a radiation track but are locatednearby may express damage or alterations in normalfunction, presumably after communication between the 'hit'cell and neighboring cells occurs. This has been termed the ` bystander effect'.
3. The progeny of a cell that survives radiation exposure mayhave increased probabilities for mutation. This has beentermed 'genomic instability'.

Chronic radiation exposure
Exposure to ionizing radiation over an extended period of time iscalled chronic exposure. The natural background radiation is chronicexposure, but a normal level is difficult to determine due tovariations. Location and occupation often affect chronic exposure.

Acute radiation exposure
Acute radiation exposure is an exposure to ionizing radiation whichoccurs during a short period of time. There are routine briefexposures, and the boundary at which it becomes significant isdifficult to identify. Extreme examples include

- Instantaneous flashes from nuclear explosions.
- Exposures of minutes to hours during handling of highlyradioactive sources.
- Laboratory and manufacturing accidents.
- Intentional and accidental high medical doses.
  The effects of acute events are more easily studied than those ofchronic exposure.

Minimizing health effects of ionizing radiation
Although exposure to ionizing radiation carries a risk, it is impossibleto completely avoid exposure. Radiation has always been present inthe environment and in our bodies. We can, however, avoid undueexposure.Although people cannot sense ionizing radiation, there is a range ofsimple, sensitive instruments capable of detecting minute amountsof radiation from natural and man-made sources.Dosimeters measure an absolute dose received over a period oftime.

Ion-chamber dosimeters resemble pens, and can be clipped toone's clothing. Film-badge dosimeters enclose a piece ofphotographic film, which will become exposed as radiation passesthrough it. Ion-chamber dosimeters must be periodically recharged,and the result logged. Badge dosimeters must be developed asphotographic emulsion so the exposures can be counted andlogged; once developed, they are discarded.Geiger counters and scintillometers measure the dose rate of ionizing radiation directly.

In addition, there are four ways in which we can protect ourselves from radiations:
Time: For people who are exposed to radiation in addition to naturalbackground radiation, limiting or minimizing the exposure time willreduce the dose from the radiation source.

Distance: In the same way that the heat from a fire is less intensethe further away you are, so the intensity of the radiation decreasesthe further you are form the source of the radiation. The dosedecreases dramatically as you increase your distance from thesource.

Shielding: Barriers of lead, concrete, or water give good protectionfrom penetrating radiation such as gamma rays and neutrons. Thisis why certain radioactive materials are stored or handledunderwater or by remote control in rooms constructed of thickconcrete or lined with lead. There are special plastic shields whichstop beta particles and air will stop alpha particles. Inserting theproper shield between you and the radiation source will greatlyreduce or eliminate the extra radiation dose.

Shielding can be designed using halving thicknesses, the thicknessof material that reduces the radiation by half. Halving thicknesses forgamma rays are discussed in the article gamma rays.

Containment: Radioactive materials are confined in the smallestpossible space and kept out of the environment. Radioactiveisotopes for medical use, for example, are dispensed in closedhandling facilities, while nuclear reactors operate within closedsystems with multiple barriers which keep the radioactive materialscontained. Rooms have a reduced air pressure so that any leaksoccur into the room and not out of it.

In a nuclear war, an effective fallout shelter reduces humanexposure at least 1,000 times. Most people can accept doses ashigh as 1 Gy, distributed over several months, althoughwith increased risk of cancer later in life. Other civil defensemeasures can help reduce exposure of populations by reducingingestion of isotopes and occupational exposure during war time.One of these available measures could be the use of potassiumiodide (KI) tablets which effectively block the uptake of dangerousradioactive iodine into the human thyroid gland.

❖ **Noise**

Noise is defined as unwanted sound. Sound is any pressurevariation or a stimulus that produces a sensory response in thebrain. The compression and expansion of air created when anobject vibrates.

Magnitude of Noise Hazard

Approximately 30 million workers are exposed to hazardous noiseon the job and an additional 9 million are at risk for hearing loss fromother agents such as solvents and metals. Noise-induced hearingloss is one of the most common occupational disease and thesecond most self-reported occupational illness or injury.

Industry specific studies reveal that:

- 44% of carpenters and 48% of plumbers reported that theyhad a perceived hearing loss.
- 49% of male, metal/non-metal miners will have a hearingimpairment by age 50 (vs. 9% of the general population)risingto 70% by age 60.

While any worker can be at risk for noise-induced hearing loss in theworkplace, workers in many industries have higher exposures todangerous levels of noise. Industries with high numbers of exposedworkers include: agriculture; mining; construction; manufacturingand utilities; transportation; and military.

Industrial Noise

Although the problem of noise was recognized centuries ago, forexample Ramazini in 1700 described how workers who hammercopper have their ears injured due to exposure to the sound. Theextent of the problem, which was caused by such noise, was not feltuntil the Industrial Revolution in England. The increasingmechanization in industries, farms, transport and others are likely tobe more intense and sustained than any noise levels experiencedoutside the work place.Industrial noise problems are extremely complex. There is no“standard " programme that is applicable to all situations. However,industries are responsible to consider and evaluate their noiseproblems and to take steps toward the establishment of effectivehearing conservation procedures.

The effectiveness of hearing conservation program depends on thecooperation of employees, supervisors, employers, and othersconcerned. The management responsibility is to takemeasurements, initiating noise control measures, undertaking theaudiometer testing of employees, providing hearing protectiveequipment with sound policies, and informing employees of thebenefits to be derived from a hearing conservation programme.

General Class of Noise Exposure

There are three general classes into which occupational noiseexposure may be grouped.

1. *Continuous Noise:* Normally defined as broadband noise ofapproximately constant level and spectrum to which anemployee is exposed for a period of eight hours per day or 40hours a week.
2. *Intermittent Noise:* This may be defined as exposure to a givenbroadband sound pressure level several times during a normal working day
3. *Impact (impulse) type Noise:* is a sharp burst of sound. Asophisticated instrumentation is necessary to determine thepeak levels for this type of noise.

Effects of noise exposure

Noise is a health hazard in many occupational settings. Effects ofnoise on humans can be classified into various ways. For example,the effect can be treated in the context of health or medical problemowing to their underlying biological basis. Noise induced hearingloss involves damage to the structure of the hearing organ.

The effects of noise on humans can be classified into two types:

- Non auditory effect
- Auditory effect

Non-auditory effects

This consists of fatigue, interference with communication, decreasedefficiency and annoyance.

Auditory effects

Auditory effects consist of permanent or temporary hearing loss. Theear is especially adapted and most responsive to the pressurechanges caused by airborne sound or noise. The outer and middleear structures are rarely damaged by exposure to intense soundenergy except explosive sounds or blasts that can rupture the eardrum and possibly dislodge the ossicular chain. More commonly,excessive exposure produces hearing loss that involves injury to the cells in the organ of corti within the cochlea of the inner ear.

Noise-induced hearing loss

Work-related hearing loss continues to be a critical workplace safetyand health issue. The American National Institute for Occupational Safety andHealth (NIOSH) and the Occupational Safety and Health Community listed hearing loss as one of the 21 priority areas for occupational health research. Noise-induced hearing loss is 100 percentpreventable but once acquired, it can be permanent andirreversible. Therefore, prevention measures must be taken byemployers and workers to ensure the protection of workers' hearing.

Prevention of noise exposure

OSHA requires a five phase hearing conservation programme for
Industrial setings:

1. Noise Monitoring
2. Audiometric (Hearing) Testing
3. Employee Training
4. Hearing Protectors
5. Recordkeeping

❖ **Lighting/Illumination**

Good and sufficient lighting is aimed at promoting productivity,safety, health, well being and pleasant working conditions at aneconomical cost.

Purpose of good lighting

- help provide a safe working environment;
- Provide efficient and comfortable sight
- reduce losses in visual performances.

Effects of Poor Illumination

Some less tangible factors associated with poor illumination areimportant contributing causes of industrial accidents. These caninclude:

- direct glare
- reflected glare from the work
- dark shadows which may lead to excessive visualfatigue
- visual fatigue, itself may be a causative factor inindustrial accidents
- delayed eye adaptation when coming from brightsurroundings into darker ones .

3.3.2 Mechanical Hazards

Mechanical factors include unshielded machinery, unsafe structuresat the workplace and dangerous unprotected tools are among themost prevalent hazards in both industrialized and developingcountries. They affect the health of a high proportion of theworkforce. Most accidents could be prevented by applying relativelysimple measures in the work environment, working practices, andsafety systems and ensuring appropriate behavioural andmanagement practices. This would significantly reduce accidentrates within a relatively short period of time.

Accident preventionprogrammes are shown to have high cost-effectiveness and yieldrapid results. However, ignorance of such precautions, particularly insectors where production has grown rapidly, has led to increasingrates of occupational accidents.Workers who use hand tools such as picks, hammers, shovels, orwho habitually kneel at their work may suffer from “beat" condition ofthe hand, knee or elbow. Beat hand is subcutaneous cellulites,which occurs among miners and stoker caused by infection oftissues devitalized by constant bruising.

3.3.3 Chemical Hazards

Average annual world production of chemicals amounts to an estimated 400 million tones. There are between 5 to 7 million known chemicals, however, only 70,000 to 80,000 are on the market, with 1,000 or so being produced in substantial quantities. In North America, around 1,000 to 1,200 are produced annually (50 % are polymers). In Western Europe, some 150 to 200 new substances are registered each year. Of the 70,000 to 80,000 chemicals only 5 to 10 %(i.e., 500 to 7,000 should be considered hazardous; 150 to 200 of these are carcinogenic. In Nigerian where data are not available it can be estimated that cases would be staggering.

Effects of chemical hazards are dependent on their:

- Amount
- Concentration
- Time of exposure
- Mode of entry to the body
- Age of the exposed workers
- Sex of the exposed workers
- Health status of the exposed workers
- Resistance of the exposed workers

Effects of Chemical Hazards

The effects of chemical agents are as follows:

1. Asphyxiation
2. Systemic intoxication
3. Pneumoconiosis
4. Carcinogens
5. Irritation
6. Mutagencity
7. Teratogenicity

Among all chemical agents in work place the most notorious andmost in contact with the skin or respiratory system that deserveattention is solvent.

Solvent

In most occupational settings or industries a potential threat to thehealth, productivity and efficiency of workers is their exposure toorganic solvents. Exposure to solvents occurs throughout life.Example, organic solvent vapor inhaled by a mother could reach thefetus.

Classification of Solvents

The term solvent means materials used to dissolve another materialand it includes aqueous or non-aqueous system. Aqueous solutionsinclude those based in water.

Example:

1. Aqueous solution of acids
2. Aqueous solution of alkalis
3. Aqueous solution of detergents.

Aqueous solutions have low vapor pressure thus the potentialhazard by inhalation and subsequent systemic toxicity is not great.Examples of non-aqueous solutions include:

- Aliphatic hydrocarbons.
- Aromatic hydrocarbons.
- Halogenated hydrocarbons.
- Cyclic hydrocarbons.

The solvent we are concerned in occupational health and safety willinclude any organic liquid commonly used to dissolve other organicmaterial.

These are:

- Naphtha
- Mineral spirits
- Alcohol, etc.

Effects of Solvents

The severity of a hazard in the use of solvents and other chemicalsdepends on the following factors:

1. How the chemical is used.
2. Type of job operation, which determines how the workers areexposed.
3. Work pattern.
4. Duration of exposure.
5. Operating temperature.
6. Exposed body surface.
7. Ventilation rates.
8. Pattern of airflow.
9. Concentrations of vapors in workroom air.
10. House keeping

Health Effect of Solvent Exposure

The effect of solvents varies considerably with the number and typeof halogen atoms (fluorine and chlorine) present in the molecules.Carbon tetrachloride, which is a highly toxic solvent act acutely onthe kidney, the liver, gastro intestinal tract (GIT). Chronic exposureto carbon tetrachloride also, damages and cause liver cancer. Thissolvent should never be used for open cleaning processes wherethere is skin contact or where the concentration in the breathingzone may exceed recommended level.

Fire and Explosion

Using non-flammable solvents can minimize the potential for this orsolvents with flash point greater than 60 degree Celsius or 140degree Fahrenheit. However the non-flammable halogenatedhydrocarbons decompose when subjected to high temperature andgive off toxic and corrosive decomposition products. If flammablesolvents with flash point less than this are used precaution must be taken to:

- Eliminate source of ignition such as flames, sparks, hightemperature smoking etc.
- Properly insulate electrical equipment when pollutants arereleased outdoors.

Solvent hydrocarbons are important compounds in the formation ofphotochemical smog. In the presence of sunlight they react withoxygen and ozone to produce Aldehyde, acids, nitrates, and otherirritant and noxious compounds. The great portion of hydrocarbonscontributing to air pollution originates from automobiles andindustries.

Dangerous chemical substances

Many dangerous substances are used in industry, commerce,agriculture, research activities, hospitals and teachingestablishments.The classification of dangerous substances is based largely on thecharacteristic properties of such substances and their effects onman. Legislation on this subject also requires the provision of aspecific pictorial symbol on any container or package.

The following terms are used in the classification of dangeroussubstances in the classification, packing and labeling of dangeroussubstances regulations 1984.

A. Corrosion
B. Oxidizing
C. Harmful
D. Very toxic and toxic
E. Irritant
F. Highly flammable
G. Explosive

A. Corrosive

Hazard: Living tissues as well as equipment are destroyed oncontact with these chemicals.
Caution: Do not breathe vapors and avoid contact with skin eyes,and clothing

B. Oxidizing

Hazard: ignite combustible material or worsen existing fire andthus make fire fighting more difficult.
Caution: Keep away from combustible material. Restrict smokingin that area.

C. Harmful

Hazard: Inhalation and insertion of or skin penetration by thesesubstances is harmful to heath.
Caution: Avoid contact with the human body, including inhalationof vapors and in cases of malaise, a doctor should be consulted.

D. Very toxic and toxic

Hazard: The substances are very hazardous to health whetherbreathed, swallowed or in contact with the skin and mayeven lead to death.
Caution: Avoid contact with human body, and immediatelyconsult a doctor in case of malaise.

E. Irritant

Hazard: May have an irritant effect on skin, eyes and respiratoryorgans
Caution: Do not breathe vapors and avoid contact with skin andeye

F. Highly Flammable

Hazard: Substances with flash point less than 60 0 C or 140 0F
Caution: keep away source of ignition.

G. Explosive

Hazard: Substances which may explode under certain condition
Caution: Avoid shock, friction, sparks and heat.

Chemical Hazards Evaluation
- Toxicity assessment
- Work activity/risk assessment evaluation
- Assessment of controls effectiveness to block routes of entry
- Exposure monitoring
- Recommendations for improvement

Monitoring Exposure of Chemical Hazards:
Chemical hazards can be monitored using:
- Special instruments : infrared absorption, photoionization,gaschromatography
- Detector tubes
- Air sampling and lab analysis
- Professional judgment

Engineering Controls of Chemical Hazards:
Engineering strategies for chemical hazards include:
- Substitution i.e. use of lower toxicity materials
- Enclose processes and otherwise engineer for lowemission / low risk

- Provide local exhaust to remove air-borne agents
- Local exhaust ventilation
- Need to have even air flow for hoods
- Need to design for adequate capture velocity -usually about 100 feet/minute
- Need sufficient make up air
- Use ACGIH Ventilation Manual for design
- Reduce exposure time
- Better procedures
- Training
- PPE - gloves, face shields, respirators
- Remote Operation

3.3.4 Biological Hazards

Many biological agents such as viruses, bacteria, parasites, fungi,moulds and organic dusts have been found to occur in occupationalexposures. In the industrialized countries around 15 % of workersmay be at risk of viral or bacterial infection, allergies and respiratorydiseases. In many developing countries the number one exposure isbiological agents.HIV/AIDS, Hepatitis B and C viruses and other blood bornepathogens, tuberculosis infections (particularly among health careworkers), asthmas (among persons exposed to organic dust) andchronic parasitic infections (particularly among agricultural andforestry workers), are the most common occupational diseases thatresult from such exposures.

Exposure to biological hazards in workplace results in a significantamount of occupationally associated diseases.Biological hazards include viruses, bacteria, fungus, parasites, orany living organism that can cause disease to human beings.

Biological hazards can be transmitted to a person through:

a. Inhalation
b. Injection
c. Ingestion
d. Skin contact

Contracting a biohazard depends on:

a. The combination of the number of organisms in theenvironment.
b. The virulence of these organisms
c. The susceptibility of the individual
d. Existence of physical/chemical stresses in the environment.

Classification of Biohazard Agents

Knowledge of biohazard and their groupings is important to decide onwhat to do to safeguard the workers from these hazards. There are twopoints that are important to remember. These are:

1. Any accident involving biohazard material can result ininfection.
2. When working with biological agents or materials for which its Epidemiology and etiology is not known or not completelyunderstood, it must be assumed that the materials constitute abiological hazard.

Occupational Exposure to Biohazards

The most obvious work place in which employees are subjected tohazards as a result that the work requires handling and manipulation of biological agents include: surgery, autopsy, contaminateddischarges, blood, pipettes, laboratory specimens, etc. Occupational settings where the risk of contracting biohazard is high include:

1. **Research Laboratories**

   Health personnel such as laboratory technicians and scientistsworking on biological specimens are at risk with biological hazards inthe laboratory. Specimen such as blood, pus, stool and other tissuesamples may expose the workers to hazards such as HIV, Hepatitis, etc.

2. **Health Care Facilities**

   Many potential biological agents exist in hospital environment.These are bacterial infection and viral agents. Those working inlaundry, housekeeping, laboratory, central supply, nursing stationand dietary are highly exposed to biohazard from the patient theyhandle, from the specimen they collect and from the cloth, needleand pans they handle and from their general day to day activities. Various settings in health care facilities susceptible to biohazard include:

   - **Laundry Sections**

     Workers in laundry are exposed to discharges from patients byvirtue of the fact that contact with linen (bed sheet), nightdressesand washable articles that are sent to the laundry for cleaning everyday.Control of infection or exposure in the hospital laundry section is possible only if workers andhospital administration adhere to the following:

     1. All linen should be placed in plastic or other bags at the bed siderather than carried carelessly across the corridor or through thehalls to where collection bags or the laundry is collected.

2. Laundry bags should be colour-coded in order to alert laundryworkers that, what is contained in the bags is potentiallyhazardous.
3. When the soiled laundry item reached the laundry the contentsof the bags should be emptied directly into the washing basin,machine or trough.
4. Employees responsible for sorting and folding linens can also besources of infection as a result of poor personal hygiene.
5. Thorough hand washing and the use of rubber gloves areessential and basic infection control methods.

- **Housekeeping**

  Housekeepers in hospitals are the single highest group exposed toinfectious biological agents.The areas and condition of contaminationare:

  1. Contact with discarded contaminated disposable materialsduring all general cleaning activities.
  2. Widespread use of disposable materials, especially those usedin intravenous administration and blood collection.
  3. Contaminated hypodermic needles and intravenous catheters
  4. Dry sweeping of the floor does not remove many microbes. Itrather pushes dust and other materials from one area to theother. When mops and brooms are improperly treated dust isdispersed back into the air.

- **Central Supply**

  The most serious problem in this department is the cleansing ofsurgical instruments. Grossly contaminated materials should besterilized in an autoclave before any handling or rinsing.Scrubbing action is much more efficient than soaking, but it is duringscrubbing that exposure to biohazard is the greatest. Direct injectionof microorganisms is possible if the skin is punctured with dirtyinstruments or if the skin has a lesion that comes into contact with contaminated instruments.

- **Health care staff**

  The possibility of exposure to infection of health care professionalsthat have direct contact with patients is always present. Infectioncan be spread in health care facilities through:-

  - Patient to patient
  - Patient to other staff
  - Patient to his/her own family

- Patient to visitors especially if consulting with familymembers of the patient

Health care workers are not the only persons susceptible to contracting diseases.Others are

- Patient
- Waste handlers and transporters
- Laundry staffs

Poor health care waste management system hazardous to:-

- Health care workers
- Patients
- Visitors
- Community
- Environment

To avoid such contamination health care workers should:

- Dispose of contaminated equipment properly so that no healthhazard is exposed to infect others.
- Hands should be thoroughly washed with soap and water aftervisiting each patient to minimize the chance of spreadingharmful infection or organisms from patient to patient.
- Gowns, masks and caps must be worn whenever necessary andremoved before entering clean areas such as rest areas andlunchrooms.
- **Dietary Sections**
  Staffs involved in food preparation are exposed to infection frominfectious agents such as salmonella, botulism, amoeba andstaphylococcus, which can result from contact with raw fish, meat,and some vegetables contaminated by sewage or human waste ordirty water.

Primary prevention against infection or contamination of the food include:

1. Proper handling of food products (raw or cooked)
2. Use clean hands and garments in the food processing areas
3. No skin lesion of food handlers
4. Refrigeration of food products at a safe temperature level inorder to prevent growth of bacteria.
5. Adequate cooking of foods.

The problem of biological hazard in health care delivery system is increasing because of:

1. Inadequate sanitation, disinfection and sterilization methods.
2. Increase in drug as well as chemical resistant strains ofmicrobes.
3. Increase of high-risk patients (HIV/AIDS and TB).

3. Agriculture

Occupational exposures to biohazard also occur in agriculture.There are three types of relationships in terms of diseasetransmission between humans and animals. These are:

- Disease of vertebrate animals transmissible to human and otheranimals (Zoonosis)
- Disease of humans transmissible to other animals(Anthropozooonois)
- Disease of vertebrate animals chiefly transmissible to humans(Zooanthroponosis)

Zoonosis

It consists of viral, bacterial, rickettsial, fungal, protozoal, andhelminthic disease. Among the most important throughout the worldare: Anthrax, brucellosis, tetanus, encephalitis, leptospirosis, rabies,and salmonellosis. The infection could enter the body throughinhalation, ingestion, or through the skin or mucus membrane.

Biohazard Control Programme

1. *Employee health*

This can be ensured through:

- Pre-placement examination for new employee.
- Periodic physical examination as part of a surveillanceprogramme.
- Vaccination.

2. *Laboratory Safety and Health*

This can be realized through:

- Employee training
- Avoid, if possible, entering into a biohazard areas.
- Avoid eating, drinking, smoking and gum chewing inbiohazard areas
- Wearing personal protective equipment is always advisable.

3. *Biological Safety Cabinet*

This is concerned with protecting workers from exposure to aerosols especially whenthere is contact with biohazards in laundry activities.

4. *Animal Care and Handling*
   - Periodic examination,
   - Disposal of manure,
   - Cleanliness,
   - Collection of medical history and
   - Treatment.

3.3.5 Ergonomic Hazards

Ergonomics, also known as human engineering or human factors engineering is the science of designing machines, products, andsystems to maximize the safety, comfort, and efficiency of thepeople who use them. Ergonomists draw on the principles ofindustrial engineering, psychology, anthropometry (the science ofhuman measurement), and biomechanics (the study of muscularactivity) to adapt the design of products and workplaces to people'sizes and shapes and their physical strengths and limitations.

Ergonomists also consider the speed with which humans react andhow they process information, and their capacities for dealing withpsychological factors, such as stress or isolation. Armed with thiscomplete picture of humans interact with their environment,ergonomists develop the best possible design for products andsystems, ranging from the handle of a toothbrush to the flight deck ofthe space shuttle.Ergonomists view people and the objects they use as one unit, andergonomic design blends the best abilities of people and machines.Humans are not as strong as machines, nor can they calculate asquickly and accurately as computers. Unlike machines, humansneed to sleep, and they are subject to illness, accidents, or makingmistakes when working without adequate rest. But machines arealso limited—cars cannot repair themselves, computers do notspeak or hear as people do, and machines cannot adapt tounexpected situations as humans. An ergonomically designedsystem provides optimum performance because it takes advantageof the strengths and weaknesses of both its human and machinecomponents.

In general, ergonomics deals with the interaction between humansand such additional environmental elements such as heat, light,sound, atmospheric contaminants and all tools and equipmentpertaining to the work place.Ergonomics or the proper designing of work systems based onhuman factors has the following advantages:

1. There will be more efficient operations
2. There will be fewer accidents
3. There will be reduced training time

4. There will be fewer costs of operations
5. There will be more effective use of workers or personnel.

The goal of "Ergonomics" or human factors ranges from makingwork safe to humans, and increasing human efficiency and wellbeing.To ensure a continuous high level performance, work systemmust be tailored to human capacities and limitations measured byanthropometry and biomechanics.

Ergonomic Hazards

Between 10% and 30% of the workforce in industrial countries andbetween 50% and 70% in developing countries may be exposed toheavy physical workload or to unergonomic working conditions suchas lifting and moving of heavy items or repetitive manual tasks.Repetitive tasks and static muscular load are found in manyindustrial and service occupations. In many industrial countriesmusculoskeletal disorders are the main cause of both short-term andpermanent work disability, which can cause economic losses thatmay amount to 5% of the GNP.

Most exposures can be eliminated or minimized throughmechanization, improvement of ergonomics, and better organizationof work and training. In particular, the growing numbers of elderlyworkers and the female workforce require constant vigilance fromthose responsible for the work organization.Improving the conditions of the work environment and opportunitiesfor providing workers' health, safety and well-being essentially meanscontributing to sustainable improvement of ergonomics. Localperceptions about ergonomics in many countries have not capturedheadlines in the newspapers. However safe and hygienicworkplaces contribute to sustainable development and this issue canbe raised through proper media exposure.

Principles of Biomechanics

Biomechanics deals with the functioning of the structural element of the body andthe effect of external and internal forces on various parts of thebody.Taking an example of "lifting" an object from the ground biomechanicsseek relevant information:

1. What is the task to be performed (task variable)
2. Would the person be able to do the task (human variable)
3. What is the type of work environment (environmental variable)

Task variable

- Location of object to be lifted
- Size of object to be lifted

- Height from which and to which the object is to be lifted
- Frequency of lift
- Weight of object
- Working position

Human Variable

- Sex of worker
- Age of worker
- Training of worker
- Physical fitness of worker
- Body dimension of worker

Environmental variable

- Extremes of temperature (hot/cold)
- Humidity
- Air contaminants

Work physiology

People perform widely different tasks in daily work situation. Thesetasks must be matched with human capabilities to avoid "overloading" which may cause the employee to breakdown, sufferreduced performance capability or even permanent damage.

Matching People with their Work

It is important to match human capabilities with the relatedrequirements of a given job. If the job demands are equal to theworker's capabilities or if they exceed them, the person will be undermuch strain and may not be able to perform the task.

Work classification

The work demands are classified from light work to extremely heavyin terms of energy expenditures per minute and the relative heartrate in beats per minute. For example the energy requirement forlight work is 2.5 Kcal/minute and the heart rate is 90 beats rate perminute, while it was extremely heavy work energy requirement is 15Kcal/minute and heart beat is 160/minute.

Workstation design

Workstation means the immediate area where the person isperforming his/her duties. The goal of designing a workstation is topromote ease and efficiency of the person’s performance.Productivity will be affected if the operator is uncomfortable and theworkstation is awkwardly designed.

Workplace design

Workplace is the establishment or department where the person orworker is performing his/her duties. The most basic requirement fora workplace is that it must accommodate the person working in it.

Specifically this means that:

1. The workspace for the hands should be between hip andchest height in front of the body.
2. Lower location are preferred for heavy manual work.
3. Higher locations are preferred for tasks that require closevisual observations.

Another key ergonomic concept is that workplace should bedesigned relating the physical characteristics and capabilities of theworker to the design of equipment and to the layout of the workplace.

When this is accomplished:

- There is an increase in efficiency
- There is a decrease in human error
- Consequent reduction in accident frequency.

Design is accomplished after learning what the worker's jobdescription will be, kind of equipment to be used for that process andthe biological characteristic of the person (worker).

Workspace dimension

Workspace dimension can be grouped in three basic categories:
minimal, maximal, and adjustable dimensions.

- Minimal workspace provides clearance for ingress and egress inwalkways and doors.
- Maximal workspace dimensions permit smaller workers to seethe equipment.This is ensured by selecting workspace dimension over which asmall person can reach or by establishing control forces that aresmall enough so that even a weak person can operate theequipment.
- Adjustable dimensions permit the operator to modify the workenvironment and equipment so that it conforms to thoseindividuals on particular set of anthropometric characteristics.

Effects of non ergonomic working conditions

The effects of a non-ergonomic work environment include:

- Tendosynovitis
- Bursitis

- Carpal tunnel syndrome
- Raynaud's syndrome ("white fingers")
- Back injuries
- Muscle strain

Preventing Ergonomic Hazards

To avoid ergonomic hazards the following points should be considered:

- Sensibility and perceptibility (visual,audible,tactile)
- Kinetic ability and muscular power or strength
- Intelligence
- Skill/Ability to learn a new technique or skill
- Social and group adaptability
- Kinetic conditions (body size or physicalconstitution)
- Effect of environmental conditions on human ability
- Long term short term or short term adaptable limitsof man(desirable or normal, compensatory or fatal)
- Reflexion and reaction patterns
- Mode of living (custom/culture) and sex distinction
- Racial differences
- Human relationship
- Factors that affect on synthetic judgment

3.3.6 Psychosocial hazards

Up to 50% of all workers in industrial countries judge their work to be"mentally heavy". Psychological stress caused by time pressure,hectic work, and risk of unemployment has become more prevalentduring the past decade. Other factors that may have adversepsychological effects include jobs with heavy responsibility forhuman or economic concerns, monotonous work or work thatrequires constant concentration.Others are shift-work, jobs with the threat of violence, such as policeor prison work, and isolated work. Psychological stress and overloadhave been associated with sleep disturbances, burn-out syndromes, stress, nervousness and depression.

There is also epidemiologicalevidence of an elevated risk of cardiovascular disorders, particularlycoronary heart disease and hypertension.Within the work environment emotional stress may arise from avariety of psychosocial factors, which the worker findsunsatisfactory, frustrating, or demoralizing.
For example:

- A peasant who migrates from the rural areas to a city will face entirely different environment if he/she start to work in anindustry.

In his /her rural life he used to work at his /her ownspeed but in the factory he may have to work continuously atspeeds imposed by the needs of production.

- Workers may be working in shifts that will expose them tounusual hours. They may upset their family's life as a result oftheir work conditions.
- Workers may be working with a person who is paid more butwho is incapable of working.
- Financial incentives are too low etc.

These and other stresses will have adverse psychosocial problemson workers.Reduction of occupational stresses depends not only on helpingindividuals to cope with their problems but also on:

1. Improved vocational guidance,
2. Arrangement of working hours,
3. Job design, and work methods;
4. Good management.

4.0 CONCLUSION

Hazards are significantly associated with occupational injuries, diseases and deaths. The relationship between occupational hazards and occupational disorders is so close that one can confidently say that there can be not disorder if there is no hazard. However, since hazards are unavoidable in the work environment, effort must be made to reducing the risk of their manifestations. This effort will however begin proper identification of these hazards since identification precedes risk reduction efforts. The module, beyond mere identification, also covers purposes and benefits of hazard identification and classification of hazards in an occupational setting.

5.0 SUMMARY

- Hazard is simply a source of danger like injury disease or death. Occupational hazard refers to anything in the work environment or work process that can result in injury, disease or death.
- Risk in occupational health denotes the likelihood of hazard occurrence and the magnitude of its effect. Occupational health strategy is targeted at reducing hazard risk to the barest minimum to ensure that it does not occur at all, and if, by chance it does occur, to reduce its effects.

- The purpose for hazard identification include: to obtain information regarding occupational stressors, to collect information on the work environment and conditions, to obtain and document information on the threshold limit values for toxic substances, to gather information on the effects of exposure to work hazards, to generate data on exposure levels of workers to hazardous substances and to determine where occupational health problem or potential problem lies with a view to responding appropriately.
- The greatest importance of hazard identification is that it saves life, resources and efforts. This is because it empowers preventive actions against occupational health problems.
- The process of hazard identification include: observing the workplace to detect hazards, investigating workers' complaint, keeping and studying records of occupational accidents, keeping record of sicknesses and illness trend among workers and gathering information through simple research concerning workers' health concerns among others.
- Occupational hazards can be classified into six: physical, mechanical, chemical, biological, ergonomic and psycho-social hazards.

6.0 TUTOR-MARKED ASSIGNMENT

1. What is occupational hazard?
2. State five purposes of identification of occupational hazards?
3. State five ways of occupational hazard identification
4. What are the classifications of occupational health hazards

Answer to Tutor Marked Assignment
Occupational Hazard
This is anything in the work environment or work process that is capable of causing injury, disease or death to workers.

Purposes of Occupational Hazard Identification
The purpose of occupational hazard identification include:

1. to obtain information regarding occupational stressors,
2. to collect information on the work environment and conditions,
3. to obtain and document information on the threshold limit values for toxic substances,
4. to gather information on the effects of exposure to work hazards,
5. to generate data on exposure levels of workers to hazardous substances and

6. to determine where occupational health problem or potential problem lies with a view to responding appropriately.

How to Identify Occupational Hazards

The process of hazard identification include:

1. observing the work environment and process
2. investigating workers' health complaint,
3. keeping and studying records of occupational accidents,
4. keeping record of sicknesses and illness trend among workers and
5. gathering information through simple research concerning workers' health concerns among others.
6. considering suggestions and inputs of labour unions

Classes of Occupational Hazards

1. physical hazard
2. mechanical hazard
3. chemical hazard
4. biological hazard
5. ergonomic hazard
6. psycho-social hazard

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MODULE 4 OCCUPATIONAL ANATOMY AND PHYSIOLOGY

CONTENTS

1.0 INTRODUCTION

The focus of this module is on understanding anatomical and physiological dimension of work. The module covers basic anatomical and physiological structures and processes as they relate to occupational health and safety.

2.0 OBJECTIVES

At the end of this module, you should be able to:

- State a simple definition of anatomy and physiology as they apply to the work conditions
- Briefly explain the functions of muscles in discharging work duties and how they can be protected to prevent injuries

- Briefly explain physiological processes of blood circulation and respiration during work
- Briefly describe the place of health status in working capacity
- Briefly explain work fatigue

3.0 Main Content

3.1 Occupational Anatomy and Physiology

Anatomy deals with the study of the structural parts of human organism while physiology entails the study of the functions of these structural parts. Occupational anatomy and physiology could be defined as the study of the structural and functional body parts of humans during work performance with a view to ensuring optimal performance and safety.

3.2 Musclesand Work Performances

All physical work is done by muscles, in which the necessary energyis created. The first task of the muscles is to maintain the body in therequired posture and then toeffect the various movements. It is through them that useful work isfinally done.Muscles work by alternating contraction and relaxation of thecomponent fibres, resulting from chemical action. Muscle fibres,which are mostly arranged in groups or bundles in different parts ofthe body, cause various movements by acting on the bones.

Muscles also cause movements in internal organs.The energy required to contract the muscle fibres is provided by theoxidisation of glucides. The combustion residues include lactic acid,water and carbon dioxide. Since the chemical reactions take place within the fibres themselves, it becomes necessary for the oxygenand the fuel to be brought to these fibres and for the waste productsof combustion to be removed, either to be discharged outside or tobe re-introduced in a regeneration cycle. The working capacity ofmuscle therefore depends on the number of fibres (musculature), the capacity of the transport routes (arteries and veins), the speed ofthe transport (blood flow), the functioning of the regulatory systemwhich has to harmonise the physiological phenomena with the effortexerted, and the pulmonary function which ensures the renewal ofthe oxygen in the blood and the elimination of gaseous waste.

3.3 Bones, Joints and Work Performance

To effect movements of the body, muscles require a firm anchorage. Bones are practically rigid, thereby providing the anchor that muscles require to act. To acertain extent they are also elastic, especially in young persons. Thiselasticity, however, does not play any part in work; it is needed totake the strain of heavy loads. If the elasticity is insufficient, as isoften the case in accidents, a bone will break. Most bones in thebody are connected by joints (such as the knee, the hip and theelbow), or they are semi-rigidly connected by ligaments or cartilage(as the ribs are to the upper part of the spinal column), or they arefastened together like the bones of the skull, whose purpose is toprotect the brain.

The spinal column has quite a special structure.The vertebrae are so shaped that the upper part of the body canassume the most widely differing positions in relation to the lowerpart, and it can also rotate independently. There is a special reasonfor this structure, in that the spinal column protects the abdominalorgans. Since it can only move by arching and cannot bend like theknee, these organs always have enough room. It does happen thatin certain positions of the torso some organs are slightlycompressed, but their functions are only very slightly impaired onthis account. In order to leave the organs with the space that theyrequire and to maintain the torso in a suitable position, the vertebraeare connected by joints that are only slightly mobile and byligaments called meniscuses or intervertebral discs. Because of theirinelasticity, the meniscuses are very sensitive to repeated jolts, suchas those caused by the bumping of a vehicle that has neither springsnor shock absorbers.

The spinal column protects only the hinder part of the abdomen; therest is protected by a wall of ligaments and muscles. The musclesare superimposed and the fibres are criss-crossed so as toconstitute an envelope that is both elastic and strong. This enablesthe body to bend forwards and sideways, and hence allows it towork in a bent position. When the abdominal wall is overloaded,especially when heavy weights are lifted, the weakest points maygive way and this may lead to hernias.

The thorax, which can move only a little, protects not only the vitalorgans- the heart and the lungsbut also the top of the stomach, theliver, the gall bladder and the spleen. The vertebrae are connectedby muscles and ligaments, and the shoulder-bones and collar-bonesare connected to the chest by the same means. The back musclesplay an important part in maintaining the position of the body. Theless they are developed, the more the vertebrae are pressedtogether, and consequently the greater the risk of deformation of thespinal column. The back muscles are also needed to compensatefor the efforts made when the arms are working.

The strength of bones is invariable over a good part of a person's lifespan, and it is wrong to suppose, as often happens, that becauseold people are particularly subject to bone fractures they have softand weak bones. In fact, a predisposition to bone fractures is theresult of poor musculature that is no longer able to hold the bonestogether adequately, coupled with vagueness and lack of coordinationof movements.

3.4 Blood Circulation and Respiration during Work

One of the principal determinants of the power of muscles is theamount of blood flowing through them. The total amount of bloodmay be considered as a personal constant because normally it issubject to only slight variations. The amount of red pigment(haemoglobin) determines the amount of oxygen that can be fixed inthe blood. The velocity of the bloodstream and the volume of thevessels (arteries and veins) govern the quantity of oxygen availablein muscles. The blood is moved by the heart, first through the lungswhere it fixes the oxygen, and then through the muscles and theorgans where part of the oxygen is consumed.

From these it returnsto the heart and lungs. It is not only the size of the heart but also,and directly, the rate at which it beats (pulse) that determines theblood flow. Hence, measurement of the rate of beating or pulse is ofgreat importance in assessing the strength required to perform agiven job. Naturally, the amount of oxygen consumed is directlyproportionate to the muscular energy produced. It is, however, moredifficult to measure this than the heart rate. All that is usually done isto compare the oxygen content of the inhaled and exhaled air,whereas at the same time it is necessary to measure the respiration,which is proportionate to the effort expended.

During inhalation the lungs fill with fresh air, rich in oxygen; this airpasses through the membranes of the alveoli of the lungs, enters theblood stream and is fixed by the haemoglobin. Each cell can fix andtransport only a certain amount of oxygen. Muscular work dependson the amount of oxygen that the blood can convey to the muscles;similarly, the rate of elimination of carbon dioxide depends on theblood flow through the body. Consequently, good circulation andrespiration are of essential importance to working capacity.The heavier the demands made on muscle power, the faster theblood must flow and the faster the human must breathe, becausethe concentrations of energising substances and cells transportingoxygen are almost constant. When the composition of the blood isnormal, the amount of oxygen that it transports is sufficient forcombustion.

However, if it is too poor in haemoglobin the oxygenflow is insufficient and the muscle cannot do as much work; if, insuch a case, it is desired to intensify muscular work, the circulationof the blood must be accelerated and the shortage of haemoglobinmust be compensated by an acceleration of the rate of oxygenexchange in each muscle. In a person whose blood is poor inhaemoglobin, the amount of muscular work will be less than in aperson whose blood contains a normal amount of haemoglobin. The requirements of a muscle considered in isolation naturally dependon the work it has to do.

During periods of rest, at each heart beat the pumped blood isdistributed among the different organs in accordance with a fixedpattern. During work, an additional flow of blood must irrigate theregions producing the energy so as to feed the muscles and removethe waste products. The regulatory mechanism of the circulatorysystem works with extraordinary precision and sensitivity. It'sreaction to change must be almost instantaneous, because themovements of the body alter very quickly. One needs only to think,for example, how quickly the different muscles of the legs act in turnwhen one is walking; and the same, of course, applies to themuscles of the arms and legs, or the hands and arms, in othermovements. The blood flow per minute is regulated by the rate atwhich the heart pumps; this can be measured by the pulse, and isonly slightly influenced by variations in the size of the heart. Thequantity of blood flowing towards any particular part of the bodydepends on the cross-section of the blood vessels concerned. Theblood arrives through the arteries and leaves through the veins.

When the blood supply to a certain region has to increase, thearteries carrying it have to dilate in order to increase their carryingcapacity, as do the veins when the blood is returning to the heart.When certain regions of the body need intense irrigation, the arteriesand veins contract in other regions, in which irrigation is therebyreduced so that the circulation can meet the increased needs of thefirst-mentioned regions. It is true that the vital organs continue toreceive just enough blood to enable them to function, but in theseconditions they are not particularly active. It is, however, veryimportant to maintain the irrigation of the brain. The amount of blood required there is small in comparison with thatrequired by the large muscles, such as those of the thighs when theyare working at full capacity.

The brain however needs blood that is rich inoxygen and its activity declines when the demand for bloodbecomes too high in other parts of the body. Naturally, other organs,such as those of the digestive system, may compete with themuscles for blood supply. After meals the digestive system needs alarge quantity of blood, not only to make its own muscles work butalso to transport and distribute the products of digestion. Man shouldtherefore stop working during and immediately after meals so as notto hinder the working of the digestive tract. This is also the reasonwhy the zeal for work declines even before the meal break.

Thischanging blood distribution between organs and muscles is also dueto the regulation of circulation. The system is so responsive to thevariations with which it has to deal that it can work for severaldecades without breaking down. Thus, working capacity dependsalso on the proper working of the regulatory mechanism of thecirculation.

Basal Metabolism

A minimum expenditure of energy is always required, independentlyof any activity, and even during sleep. This is "basal metabolism". Itis the minimum energy exchange that is essential for themaintenance of life. Basal metabolism (measured in calories)depends on the weight of the body and its surface area (temperatureregulation) and varies slightly with sex and age. Such determinationsof basal metabolism as may be necessary for medical reasons or forwork study must be carried out in a specially equipped laboratory.

Static Work

So far emphasis has been only on dynamic muscular work, i.e., workdone by movements of the body. There is, however, another kind ofwork: static work, or the work of maintaining a position. Such workentails constant effort by the muscles that maintain certain parts ofthe body in particular positions (crouching, kneeling, sitting, and squating). Carrying loads on outstretched arms or on the head areexamples of static work. If the body is to maintain a certain posture,the first requirement is that the head is in such a position that thefunctioning of the brain is not hampered. Second, the posture shouldbe such that the reactions of dynamic work (for instance, whenwalking or making tractive effort) can be absorbed without loss ofbalance.

As discussed earlier, muscles work by alternating contraction andrelaxation of their component fibres. However, the work ofmaintaining a position cannot be accomplished by continuouscontraction, since muscular relaxation is indispensable to irrigationby the blood and to the removal of the waste products of oxidisation.In static work, the contraction phase of each fibre is much longerthan the relaxation phase, and there are therefore always morecontracted than relaxed muscles. Consequently, the time availablefor removing waste products is much shorter than in dynamic work,and static work causes fatigue much more quickly. A givengroup of muscles produces 15 per cent less effort in static than indynamic work. Carrying an object with outstretched arms sooncauses fatigue, and standing still for a long time may cause faintingdue to imbalance of the circulation. Work done by the hand in staticcontraction, on a tool, a work-piece, a pen or other object oftencauses pain, indicating an accumulation of waste products in themuscles. Posture during work and the manner of working thereforehave a considerable effect on output.

Thermal Regulation

If all the vital functions of the human body are to remain unimpaired,the body's internal temperature must be maintained at or about37°C. If a human lives in a cool or cold environment, he/she isconstantly dissipating a certain amount of heat. This leads to theintensification of basic combustion in order to make up for theconstant loss of calories. In adults, the basal metabolism needed forthe functions of the various organs represents between 1,200 and1,600 kcal per day, or between 0.85 and 1.1 kcal per minute. Butthis amount of heat is not enough to compensate for the lossesunless the environmental temperature is at least 20°C.

In agriculturalwork it is practically impossible to regulate the environmentaltemperature, and the clothing must therefore be adapted to theworking conditions.The additional heat produced by physical work is sometimes verygreat and may amount to several times that of basal metabolism.For an eight-hour day, depending on the effect required, theexpenditure of energy ranges from 2,000 to 3,000 kcal. The averageis therefore 4-6 kcal/min, with peaks which may reach 12 kcal/min.This great amount of heat has to be eliminated as quickly aspossible. The body dissipates heat by radiation, convection orevaporation (sweat). Radiation and convection, by which the bodycan dissipate only 2-2.5 kcal/min, are restricted by clothes. The heatlosses by radiation and convection depend primarily on thedifference in temperature between the skin and the environment,and this is regulated to a certain extent by the circulation of theblood.

The greater the amount of excess heat to be removed, the more thecirculation increases at the level of the skin and the faster the heatexchange with the environment becomes. The thermal conductivityof the skin is different in the two sexes, being lower in women than inmen.

This is why women can generally bear to be more lightlyclothed than men. The dissipation of body heat increases in adraught, which is constantly bringing cooler air into the vicinity of theskin.If the work generates more heat than can be dissipated by radiationand convection, sweat is produced, which evaporates on the skin.

The phenomenon of sweat evaporation enables large quantities ofheat to be dissipated in the environment. The larger the sweatingarea of the skin and the drier the environmental air, the greater thedissipation of heat by sweat. While for light work the humidity of theair is of no great significance, intensive work can be done only if theair is not saturated with humidity (that is, if it is comparatively dry),as otherwise the sweat cannot evaporate. Sweat can remove excesscalories only by evaporating, and this is why streaming sweatrepresents a useless waste of energy.

As evaporation depends on the environmental temperature and airmovements, clothing is an important factor here too. Since sweatingis not uniform over the whole surface of the body, underclothes mayfacilitate the dissipation of heat if they are completely soaked withsweat. Thus underclothes should rapidly absorb sweat, distribute itand ensure uniform and regular evaporation. The larger the surfaceof the garments, the more effectively will they fulfil these tasks.Natural fibres such as wool and cotton are impregnated more slowlythan synthetic fibres. Closely woven materials are less effective thanloose materials, such as knitted garments.Equatorial and tropical countries are normally regarded as "hotcountries". They may nevertheless have temperate seasons andcool upland regions (for instance, the east central African plateau,which is at an average altitude of 1,500 m and has intensivelycultivated areas up to an altitude of about 3,000 m near the equator).As a rule, workers in the tropics cannot be expected to have thesame output as those in temperate countries.

3.5 Co-ordination of Physiological Functions during Work

The foregoing brief description of some physiological functionssuggests the existence of a very precise regulatory system for thenecessary harmonisation of these functions. This regulation iscontrolled by the nerves, which receive their impulses from widelydiffering centres, most of them in the brain. It is almost entirelyunconscious and involuntary, and depends on the physiologicalautomation that keeps the body alive. The over-all co-ordination ofthe maintenance of body balance, the adaptation of respiration andcirculation and the dissipation of heat are automatic reflex functionsthat do not require any voluntary interference. Automatic regulationis surer and more precise than conscious regulation and also seemsto need a smaller expenditure of energy.

This is in fact the reasonwhy, whenever possible, man tends to replace certain processes,movements and actions by reflexes. Advantage is taken of this factin training and working. However, this natural tendency, imposed onman as it were by his physiology, has as its counterpart an attitude,varying in degree, of inertia towards changes in working habits. Infact every new process has first to be controlled by the will; only laterdoes it come within the province of reflexes, which, if necessary, willsucceed and replace reflexes controlling the processes adoptedhitherto.The precision of regulatory functions varies with the importance ofeach in the maintenance of vital equilibrium, health and welfare.

While internal temperature is regulated very precisely, the oxygencontent of the blood is less so, and the water content of the body stillless. Some types of regulation, such as that of blood supply tomuscle, are almost instantaneous; others, such as the reconstitutionof energy reserves, sometimes take several hours. Some have adaily rhythm-for instance, the alternation of activity (day) and rest(night)-and others have a periodicity of a year or more (duration ofsleep in summer and winter, variation of activity with age). Theorgans can retain their vitality only by functioning regularly; theyhave no need of prolonged rest. On the contrary, inaction mayatrophy them and put an end to the corresponding regulatoryfunction.The proper working of the regulatory system depends on healthydevelopment in childhood and adolescence, suitable training duringgrowth and continuous exercise later.

Adaptation to environment

The co-ordination of the different functions of the body is not the soletask of physiological regulation; it must also ensure the correctadaptation of the individual to the environment. This is of utmost importance for the maintenance of maximum working capacity inface of the enormous variations that may occur in the nature andplace of work. For example, muscular energy must correspondto the effort demanded, and the dissipation of heat to theenvironmental temperature. This adaptation can be easily observed by the following:

- if the intensity of the effort increases,
- the pulse and breathing ratessteadily increase too.
- The eye adapts itself automatically to theluminosity and distance of objects.

These are only a few of thecountless regulatory activities induced by stimulation from theenvironment.

3.6 Health Status and Working Capacity

Health underlies every activity of man, obligatory and non-obligatory. No worker can exceed the capacity to which his/her health status can support. Human's working capacity therefore depends on the sum total of his/herphysiological functions. It is based to some extent on a certainnatural predisposition, but more on the development and training ofthe body, muscles and regulatory organs and centres. A person'sworking capacity is thus closely bound up with his state of health.Physical work calls for certain qualities that human, if he enjoysgood health, can develop fully by training. It requires well developedmuscles, a robust skeleton, sound organ (circulatory, respiratory,renal, digestive, etc.) and a good neuro-endocrinian regulatorysystem.

3.7 Diet and Work

An adequate diet is one of the indispensableconditions of satisfactory working capacity. The more muscular worka human does, the greater must be his consumption of thesubstances required for chemical combustion. Energy reserves musttherefore be replenished by a diet rich in carbohydrates. Most of thecarbohydrates in a diet come from cereals: wheat in Europe andNorth America, rice in Asia and maize in Latin America. In Africa, carbohydrate chiefly comes from cereals and root and tuber. Human other plants are rich in carbohydrates, such as sorghum,manioc and potato.

In making bread and paste, cereals must betreated to make them more digestible; they also undergotransformation in the body. On the other hand, sugar can beabsorbed without any preparation and quickly passes into the blood,so that it is a very important food in intensive work.When a human does less strenuous work, his diet should containcorrespondingly fewer carbohydrates. It is a problem peculiar tomodern nutrition in industrial countries (in which muscular work issteadily declining and consequently the consumption ofcarbohydrates should decline to the same extent) that because ofhabit or appetite people still consume large quantities ofcarbohydrates. This leads to obesity, which is not only inimical towork but is also at the origin of human diseases.

In addition tocarbohydrates, food should contain proteins and fats, the lattercontributing to the energy balance, more especially in the internalorgans. Protein is needed in the formation of cell tissue, which isconstantly being renewed; this is why muscle too needs a supply of protein. It is obvious that an adolescent whose muscular growth isnot completed will need more protein than an adult; but the adultmust have a certain minimum amount to maintain his energybalance. The body needs various proteins, and if a diet is to bebalanced it must be adequate in quantity and quality. If it is not,there will be a food deficiency. Above all, there must be a minimum proportion (about 30 per cent) of animal protein for persons doingheavy, difficult or intellectual work.

All food is transformed in the digestive tract before being conveyedto the organs for which it is intended. Digestion is a cyclic and not acontinuous process, but since requirements in muscular energy areeither continuous (in the heart muscle, for example) or spreadevenly over the hours of the day (as in the muscles of locomotion),reserves have to be constituted. Thus food can be absorbed anddigested at the intervals fixed by meals. In healthy persons the bodyhas sufficient reserves to enable it to burn, over a period of severaldays, more substance than is supplied by the food consumed duringthose days. In the long run, however, the food intake must restorethe balance or exhaustion will result. The more energy the workdemands, the richer and more frequent the meals should be; butmeals should be spaced out if the work falls off. Thus a human doingheavy work needs five meals a day, while a tractor driver, forexample, if he is comfortably seated, is so little affected by eighthours of work that he should easily be able to manage with threemeals a day. The proper working of the digestive system is just asimportant for working capacity as are the soundness of the skeleton and the development of muscles.

3.8 Work Skill Training

Working capacity is determined by muscular development as well asby food and by the adaptation of the circulatory and respiratorysystems as well as their regulatory mechanisms. It is possible to developindividual predispositions by training, up to an advanced age, and tomaintain them at a high level.In physical training stimulations are produced by muscular work, themaximum stimulation corresponding to overwork up to the limit offatigue. A short spell of overwork, say from two to five minutes, for example, is the best form of physical training. Naturally, personssuffering from pathological changes or disorders should avoid suchefforts.

The stimulation produced by training may be deliberate, as in sport,and be intended to develop the muscles of a particular part of thebody, but it occurs automatically in all work. The greater the amountof work required of the different parts of the body, the better will bethe physical condition.

Thus varied muscular work, as encounteredin many agricultural activities, is one of the best means of achievinga harmonious development of the body. The physical developmentof adolescents should therefore be promoted systematically, bymeans of work suited to their body strength and their age. Muscularstimulation that is due to training and causes muscles to developalso strengthens certain organs that participate indirectly in muscularwork. Both the heart muscle and the regulatory mechanism ofcirculation benefit from the training constituted by steady work.The functions of each are decisive for the maintenance of a person'sworking capacity. The regulation of the circulation is a very goodexample of the organisation of an aggregate of physiologicalreflexes designed to produce the requisite effect at any point andmoment.

Physiological regulation operates at two different levels. One is involuntary and therefore outside conscious control. This regulation is essentially concerned with themaintenance of life. It comprises the regulation of the heart, thecirculation and the respiration, the regulation of the digestive system,the co-ordination of circulation and respiration, and so on. The otherconsists of regulatory mechanisms that is voluntary and therefore depends on conscious control. This aspect of regulation governs processes bound up within voluntary action. But as a result ofexercise and training, the control of work very soon passes into thedomain of automatic reflexes.

It must be supposed that unconsciousregulation is more economical, and at the same time quicker andmore precise, than conscious regulation. The performance of anyjob requires a rapid and precise system of regulation. This systemalso is subject to the laws of training: the more it is used, the better itis trained and the more serviceable it becomes.There are limits in both directions to these biological processes. Thescience of work has long concerned itself with discovering human'soptimum working capacity. The permanent optimum rate is attainedwhen the energy supply just balances the loss.

There is also a lower limit to physical work. We all know that after along spell in bed the body has lost strength and must be laboriouslyretrained for work. This is because the stimulation of training hasbeen absent for too long, and consequently the muscles, muscularmovements and organic regulation have all become too weak. Theoptimum working capacity lies between insufficient work andexcessive work; however, frequent alternation of working intensities, lightwork, normal work, and heavy work is, within certain limits, probablymore beneficial to the body than working at uniform intensity for avery long spell.

If training is to be effective, the same exercises must be repeatedoften and correctly. In simple work, the effects of training are felt verysoon, generally after a few hours. It is not necessary to repeat theexercises without a break; they can be performed on alternate days.This is very important in agricultural operations, some of whichcannot be carried on for long without a break. However, in all therepetitions the course of the process must be identical. Work operations requiring very close co-ordination of various movements orperceptions, and those involving analogous but very varied actions,need longer training periods (up to 50 or 60 hours). Here too,however, one may count on a sufficient degree of assimilation,which means that the work is performed correctly under the controlof the unconscious.

This sufficiency of assimilation of operations is particularly importantfor the agricultural worker, who can rarely concentrate on the actualwork, being frequently obliged to watch the results so as to controlquality. The farmer, acting both as the head of an undertaking andas a worker, is even more bound to watch the result of the work, sothat he has no time to see how the work is actually being carried on.Thus, for the farmer, the introduction of new processes means aheavy psychological strain, and attempts should be made to lightenit by all possible means.

3.9 Age, Aptitude and Work

No worker can work beyond the extent to which his/her age status can support. Apart from age, aptitude which connotes the potential to learn new task and undertake the work demand successfully also plays significant role in work. If the individual limits for these factors are not exceeded,working capacity can be maintained over the whole span of activelife. With age, it is true, many functional capacities decrease, as wellas aptitude for training, but this does not matter much if the workdone remains fairly constant. Moreover, the elderly worker oftenreplaces failing strength by greater skill. Re-training elderly personsfor new and arduous operations is difficult, but a man of 60 can domost field work just as well as a man of 30, except for thoseoperations wherein man reaction time may be critical. If ability towork is to be measured by age, it may be said that it can equally wellbegin relatively early and continue well beyond 65 years. The qualitydeclines only slowly with age if activity is regularly maintained. Thereis practically no wear on muscles and organs, as was once thought.However, the effects of illness increase with the years, because theaptitude of the body and its functions for training continuouslydecline. This is why convalescence period in old people is more prolongedthan in the young.

3.10 Curve of Physiological Work and Biological Rhythm

The working capacity of an individual varies in the course of the day,and does so in a rhythm that is independent of the actual work. Itincreases in the morning from 6.30 to 8 a.m., reaches its maximum at about 10 a.m. and declines towards 11 a.m. In the middle of the day, between noon and 1 p.m., it is low, whatever the meal taken, andthen it raises again. The afternoon maximum, between 2:00 and 3:00p.m., is a little lower than the morning maximum. After 4 p.m.working capacity falls rapidly. At night it is always lower than in thedaytime. No training can alter this natural rhythm. It persists evenamong persons who have worked only at night for several years;their working capacity remains greater during the day than duringthe night.

3.11 Work Fatigue

Whatever the nature and intensity of work, human, as a bio-mechanical organism has the tendency of experiencing fatigue. Fatigue is a complex physiological condition involving a reversiblelowering of working capacity. In addition to muscle fatigue due towork, which is acute,the more the work is concentrated in afew muscle groups, humans usually experience general fatigue.There are days when a person feels very tired after work; there areothers when after the same work he is less tired. Fatigue is thus asubjective phenomenon that depends on both physiological andpsychological factors.

Normal fatigue occurring at the end of the dayis usually overcome by sleep, so that when a human wakes up he isready to resume work. However, matters are not always so simple;after the night's rest some fatigue may remain, but this may beeliminated one or two days later by a good night's sleep. On theaverage, daily fatigue due to work should not exceed the maximumthat can be overcome by a night's sleep. If overwork persists, fatigueaccumulates and may cause serious trouble, or at least reduceworking capacity. Even purely muscular fatigue is overcome by rest,chiefly by nightly rest. However, local phenomena may also occur inmuscles; they are mostly due to insufficient elimination of wasteproducts, which is often the result of the manner of working as muchas of the intensity of the work.

Static effort is always particularly arduous and tiring, and this is whyattempts should always be made to eliminate it from methods of working. If this is impossible, spells of static work must be shortenedand interrupted by spells of dynamic work. If static work lasts toolong, the minimum results will be local cramp (for example, tractordrivers suffer from cramp in the right calf when the accelerator pedalis badly placed and requires excessive effort by the foot).Intense muscular fatigue and stresses on the brain and the senseorgans (eye, ear and so on) lead to considerable strain on thecentral nervous system and consequently to general fatigue, whichin turn is characterised by a general lowering of working capacity. Itwill even affect body organs that have taken scarcely any part in theeffort. The working environment can also affect the functioning of thecentral nervous system and contribute to the development of fatigue.This is more particularly so in workplaces that are dark, noisy andhot to an unhealthy extent.Monotonous work causes drowsiness and can lead to extremelyserious problems in many kinds of work.

3.12 Measurement of Physical Work

Since the degree of fatigue is not always directly proportionate to thework done, and since even today it cannot be measured, othercriteria have been sought for measuring human work. One that hasbeen applied for a long time, and is very suitable for measuringdynamic work, is the amount of oxygen consumed. This amount is infact directly related to the energy consumed, so that the amount ofoxygen consumed is a direct indication of the intensity of the work.Naturally, it can be used only to measure dynamic muscular work, tothe exclusion of static work and intellectual work which consumecomparatively little oxygen.

The consumption of oxygen is measured as follows: the subject,whose nose is pinched, has in his mouth a valve that allows him toinhale fresh air. All the exhaled air passes through a volumetriccounter which gives a reading of the amount of air breathed. Part ofthe exhaled air is collected in a vessel and then analysed in thelaboratory. The carbon dioxide content and the oxygen content aredetermined and compared with the content of the inhaled air. Thislatter content need not be specially determined unless the air hasbeen contaminated by exhaust or other gases, but can be takenfrom tables.

3.13 Oxygen Consumption

The difference between the oxygen content multipliedby the volume of air inhaled gives the oxygen consumption, fromwhich, with the aid of tables, the calorie production can be found. Tofind the number of calories produced by the work, the number due tobasal metabolism must be deducted from this result. Although theapparatus used is much less cumbersome than formerly, the valvefor breathing does inconvenience the subject and he needs a certaintime to get used to it before exact measures can be taken.

Table 4.1. Work classification according to oxygen uptake and calorie expenditure

Physiological variables	**Work intensity**	
Very light	(1/min)	Cal/min
Light	<0.5	< 2.5
Moderately heavy	0.5-1.0	2.5-5.0
Heavy	1.0-1.5	5.0-7.5
Very heavy	1.5-2.0	7.5-10
Extremely heavy	2.0-2.5	10.0-12.5
Oxygen uptake	> 2.5	> 12.5

3.14 Heart Rate

As the intensity of physical work gradually diminished, it becamenecessary to find another method of measurement independent ofoxygen consumption. A good indicator of work is the pulse. Sincethe amount of blood delivered by each heart beat is almost constantfor an individual, within certain limits, the pulse rate is a directindication of the amount of blood demanded by a particular part ofthe body. Measuring instruments are used for pulse counting duringwork. In simple investigations integrating instruments count thepulsations during a minute or a number of minutes. For more preciseinvestigations, instruments that record each pulsation are used.

Some have a small lamp which is placed under the lobe of the earand the light of which is momentarily dimmed as each surge of bloodpasses. The variation in the light is converted into electric impulsesthat are shown on the recording instrument. Other instruments pickup the nervous impulses directly by means of electrodes. Heartbeatscan be recorded electrically on magnetic tape or mechanically onpaper reels. It is essential to obtain recordings that are as accurateas possible, for it is not at all easy to interpret them. In fact, the pulserate does not depend solely on the oxygen consumption, and henceon the amount of dynamic work. Static effort will accelerate thepulse, and hence measuring the heart rate usefully supplements themeasurement of oxygen consumption.

Mental and intellectualactivities also affect the heart rate, as do many other factors,especially psychological factors such as anguish, bad temper, joyand mental effort. Their influence is seen in the circulation.Moreover, regulation of the heart rate is subject to quite precise lawsthat are related to work. For example, the rate increases before workbegins; during work it decreases to correspond with the intensity ofthe work. When the work is finished, the rate decreases slowly untilit corresponds to the rest conditions prevailing before the workbegan. If this does not occur, it must be supposed that some fatigueremains after the work. To measure this, the method just describedcan be used. When it is desired to measure the pulse rate duringwork, the rest rate must be subtracted from the rate measured.

Therest rate can be measured when the subject has rested for asufficient time lying down. It varies greatly from one person toanother, and so must be determined not only for each person separately but also several times for the same person, before andafter work. In many measurements it is better to count only thepulsations above the number corresponding to the periodimmediately preceding the work; for example, for work done in asitting position the pulse rest rate in that position would besubtracted, for work done in a standing position the rest rate wouldbe subtracted, and so on. This "starting rate" is useful in most efforttests. The "effort" pulse rate is the difference between the aggregaterate during work and the rest rate or starting rate.

Table 4.2. Classification of physical work by heart beat

Degree of effort	Heart rate (pulse/min)
Very light	<75
Light	75-100
Moderately heavy	100-125
Heavy	125-150
Very heavy	150-175
Extremely heavy	>175

Measurement of the heart rate, rather than measurement of theoxygen consumption, makes it possible to determine the limit ofcontinuous work. If the pulse remains constant duringthe work, this is within normal limits; but if the pulse ratecontinuously rises while the work remains constant, the work isexceeding the limits of normal effort. This test often brings to lightorganic defects or functional troubles that render a person unfit forheavy work.

4.0 CONCLUSION

This module shows that anatomical and physiological functions are highly dependent on the extent to which the work environment is safe and healthy for workers to discharge their duties. Occupational disease, injury or accident in the work environment affects anatomical and physiological functions of man. Almost all the systems in man and their associated organs are vulnerable to occupational disease, injury or even death. It is thus emphasized that there is need to keep the work einvrionment safe from hazards that will result in health problems in the nearest future or even immediately.

5.0 SUMMARY

- Anatomy is concerned with the study of the structural part of humans while physiology is tailored towards gaining understanding of the functions of these structures.
- The essence of occupational anatomy and physiology is focused at helping industrial workers and their managers to maintain an optimal level of health.
- Anatomical structures like the muscle, bones and joints play important role in industrial health as no tasks can be fulfilled without the above mentioned anatomical structures.
- Physiologically, the circulation of blood also makes certain vital characteristics of man possible. For instance, respiration, just like almost every other system in man is dependent on proper and adequate circulation of blood.
- Circulation involves movement of blood to and from the heart through the blood vessels.
- During work, different physiological processes take place. It is important for coordination of these numerous activities. The nerves constituting the nervous system plays important role in harmonization of these physiological functions.
- Beyond optimal physiological functioning, health status and diet are also central to work performance in the industrial setting.
- Skill training, age of workers and their aptitude also affect their work performance. Workers exposed to training adapt very well to the work environment just as do workers with high aptitude. Aged worker and under-aged workers might find it difficult to cope with the demands of the work environment.
- Workers just as every other human are biomechanical being with the tendency of getting tired. Work fatigue refers to the condition by which the worker reaches the natural limit of his/her ability to sustain a uniform muscular contraction. This way, the worker experiences muscular fatigue and in some instances, burn out.
- Work performance is usually measured using oxygen consumption or heart rate.

6.0 TUTOR-MARKED ASSIGNMENT

1. State a simple definition of anatomy and physiology as they apply to the work conditions
2. Briefly explain the functions of muscles in discharging work duties
3. Briefly describe the place of health status in working capacity
4. Briefly explain work fatigue

Occupational Anatomy and Physiology

This refers to the study of the structural and functional make-up of man in relation to work and well-being. It connotes the study of the structural and functional parts of the worker with a view of improving work performance and ensuring the safety of the worker.

Functions of Muscles in the Work Environment

Every occupational task demands some levels of movement even if done in a static position. There cannot be movement without muscular contraction, as such, the muscles are fundamental to discharging occupational demands. Chemical reactions take place within the fibres of the muscles. This way, the energy required for muscular contraction and relaxation which bring about movement is produced. However, the working capacity of muscle depends onmusculature (i.e. the number of muscle fibres), the capacity of the blood vessels (i.e. arteries and veins) the speed of blood circulation, the optimal functioning level of the nervous system and the pulmonary function (movement of blood from heart and lungs to supply oxygen) which ensures the renewal of the oxygen in the blood and the elimination of gaseous waste.

Health Status and Work Capacity

Health is central to work as no worker can exceed the extent to which his or her heart status will support him. Every worker can only perform or discharge the tasks expected of him or her based on the extent to which his/her health status will give required support. For optimal work performance, there is need for optimal health. Healthy workers record better performance than workers that are not healthy, health status in this regard transcends physical health to mental and social health. This makes it vitally important to ensure that the work environment is healthful and stimulate as well as promote health status of workers as healthy workers are dutiful workers.

Work Fatigue

This simply refers to the condition by which a worker has reached his/her limit. Work fatigue set in when the muscles have been over worked beyond their capacity leading to steady decline and if work continues, to a point where no work or no meaningful work can be done again due to mental and physical exhaustion. Giving workers break period in the course of work is important in reducing work fatigue. It is also important to ensure good work-man match. This requires assigning jobs to people who have the mental and physical capacity to discharge them. People have different abilities, as such, in arranging the work environment, good man-work match must be ensured.

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MODULE 5 OCCUPATIONAL TOXICOLOGY

CONTENTS

1.0 INTRODUCTION

This module focuses on toxic chemicals in the work place and the interaction they have with the human system. These chemicals, though harmful, can only affect humans when they find their way on or into the body system. Preventing their health effects begins with understanding their portal of entry and how to avoid them. The module also covers the various means through which these harmful chemicals enter the human body. Factors influencing the toxicity of these chemicals as well as emergency care response are also covered.

2.0 OBJECTIVES

At the end of this module, you should be able to:

- Define toxicology as it applies to the work environment
- Identify and briefly discuss at least three entry points in the human body for chemical hazards
- State at least seven factors influencing the toxicity of a chemical substance
- State emergency care for at least three portal of entry for chemical hazards.

3.0 MAIN CONTENT

3.1 Toxicology in Occupational Health

Toxicology could be defined as the study of harmful interactions between chemicalsand biological systems. Man, the other animals and plants in themodern world are increasingly being exposed to chemicals toenormous variety. These chemicals range from metals and inorganicchemicals to large complex organic molecules, yet they are allpotentially toxic.There are now many thousands of chemical substances used inindustry ranging from metals and inorganic compounds to complexorganic chemicals. The people who work in the industries which usethem are therefore at risk of exposure. Fortunately, exposure is oftenminimized by using chemicals in closed system so that operators donot come into contact with them, but this is not always the case.

In the developing countries, however, some of which are rapidly industrializing, exposure levels are higher and industrial diseasesare more common than in the fully developed countries.Consequently exposure to toxic substances in the workplace is still avery real hazard. Furthermore even in the best regulated industrialenvironment, accidents may happen and can lead to excessiveexposure to chemicals.Industrial diseases have existed ever since man beganmanufacturing on a large scale, and during the Industrial Revolution, occupational disease became common. Some of these diseases were well known tothe general public and are still known by their original, colloquialnames. These diseases were, and some still are of great importancesocially, economically and medically.

Many occupations carry withthem the risk of a particular disease or group of disease. Thus,mining has always been a hazardous occupation and miners suffersilicosis, while asbestos workers suffer asbestosis andmesothelioma, and paper and printing workers are prone to diseaseof the skin. A man spends on average one-third of his life at workand, therefore, the environment in that workplace can be a majorfactor in determining his health. Although the working environmenthas improved immeasurably over the last century, some occupationsare still hazardous despite legislation and efforts to improveconditions.

3.2 Routes/Portal of Entry for Toxic Chemicals

There are four main routes by which hazardous chemicals enter the body, inhalation, skin absorption, ingestion and injection.

1. **Inhalation:** For industrial exposure, a major, if notpredominant route of entry is inhalation. Any airbornesubstance can be inhaled. The total amount of a toxiccompound absorbed via the respiratory pathways dependson its concentration in the air, the duration of exposure, andthe pulmonary ventilation volumes, which increase withhigher work loads.

2. **Skin Absorption:**An important route of entry for somechemicals is absorption through skin. Contact of asubstance with skin results in these four possible actions:
   - The skin can act as an effective barrier
   - The substance can react with the skin and cause localirritation or tissue destruction
   - The substance can produce skin sensitization
   - The substance can penetrate skin to reach the bloodvessels under the skin and enter the bloodstream.

3. **Ingestion:**The problem of ingesting chemicals isnot widespread in the industry; most workers do notdeliberately swallow materials they handle. Nevertheless,workers can ingest toxic materials as a result of eating in contaminated work areas;contaminated fingers and hands can lead toaccidental oral intake when a worker eats or smokeson the job

4. **Injection:**Although infrequent in industry, asubstance can be injected into some part of thebody. This can be done directly into thebloodstream, peritoneal cavity, pleural cavity, skin,muscle, or any other place needle or high-pressureorifice can reach

3.3 Dose-Response Relationship/Assessment

Dose defines the actual amount of a chemical that enters the body.The dose received may be due to either acute (short) or chronic(long-term) exposure. An acute exposure occurs over a very shortperiod of time, usually 24 hours. Chronic exposures occur over longperiods of time such as weeks, months, or years. The amount ofexposure and the type of toxin will determine the toxic effect.

What is dose-response?

Dose-response is a relationship between exposure and health effectthat can be established by measuring the response relative to anincreasing dose. This relationship is important in determining thetoxicity of a particular substance. It relies on the concept that a dose,or a time of exposure (to a chemical, drug, or toxic substance), willcause an effect (response) on the exposed organism. Usually, thelarger or more intense the dose, the greater the response, or theeffect. This is the meaning behind the statement "the dose makesthe poison."

Threshold dose

Given the idea of a dose-response, there should be a dose orexposure level below which the harmful or adverse effects of asubstance are not seen in a population. That dose is referred to asthe ‘threshold dose'. This dose is also referred to as the No Observed Adverse Effect Level (NOAEL), or the No Effect Level (NEL). Theseterms are often used by toxicologists when discussing therelationship between exposure and dose. However, for substancescausing cancer (carcinogens), no safe level of exposure exists,since any exposure could result in cancer.

Individual susceptibility

This term describes the differences in types of responses tohazardous substances, between people. Each person is unique, andbecause of that, there may be great differences in the response toexposure. Exposure in one person may have no effect, while asecond person may become seriously ill, and a third may developcancer.

Sensitive sub-population

A sensitive sub-population describes those persons who are moreat risk from illness due to exposure to hazardous substances thanthe average, healthy person. These persons usually include thevery young, the chronically ill, and the very old. It may also includepregnant women and women of child-bearing age. Depending onthe type of contaminant, other factors (e.g., age, weight, lifestyle, sex) could be used to describe the population.

Dose Response Assessment

The characteristics of exposure to a chemical and the spectrum ofeffects caused by the chemical come together in a correlativerelationship that toxicologists call the dose-response relationship.

This relationship is the most fundamental concept intoxicology.To understand the potential hazard of a specificchemical, toxicologists must know both the type of effect itproduces and the amount, or dose, required to produce that effect.The relationship of dose to response can be illustrated as a graphcalled a dose-response curve.

There are two types of response curves: one that describes the graded responses of anindividual to varying doses of the chemical and one that describesthe distribution of responses to different doses in a population ofindividuals. The dose is represented on the x-axis while the response isrepresented on the y-axis. The following graph shows a simpleexample of a dose-response curve for an individual with a singleexposure to the chemical ethanol (alcohol), with graded responsesbetween no effect and death.

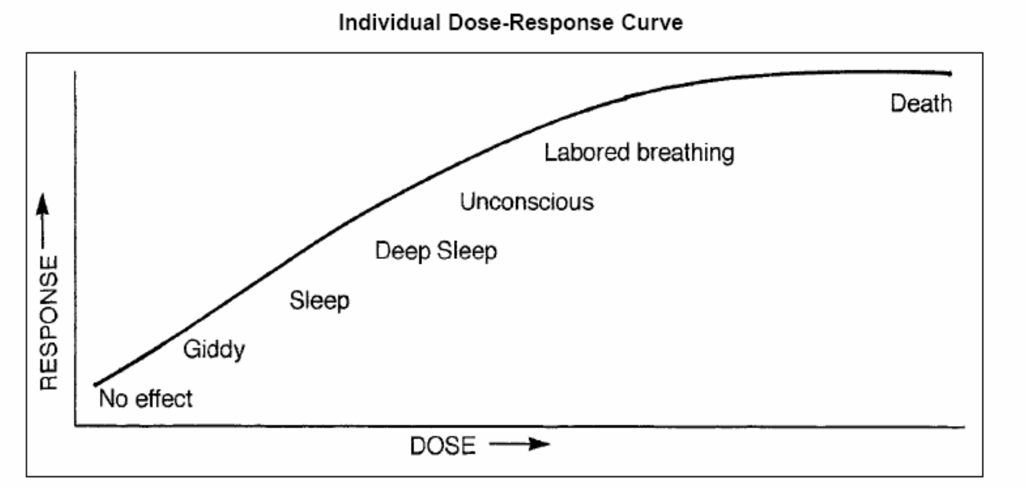

Fig. 3.3:*Individual Dose-Response Curve*
Source: Takele and Menghesha (2006)

A simple example of a dose-response curve for a population ofmice in a study of a carcinogenic chemical by Eaton and Klaassen (1996) is shown below:

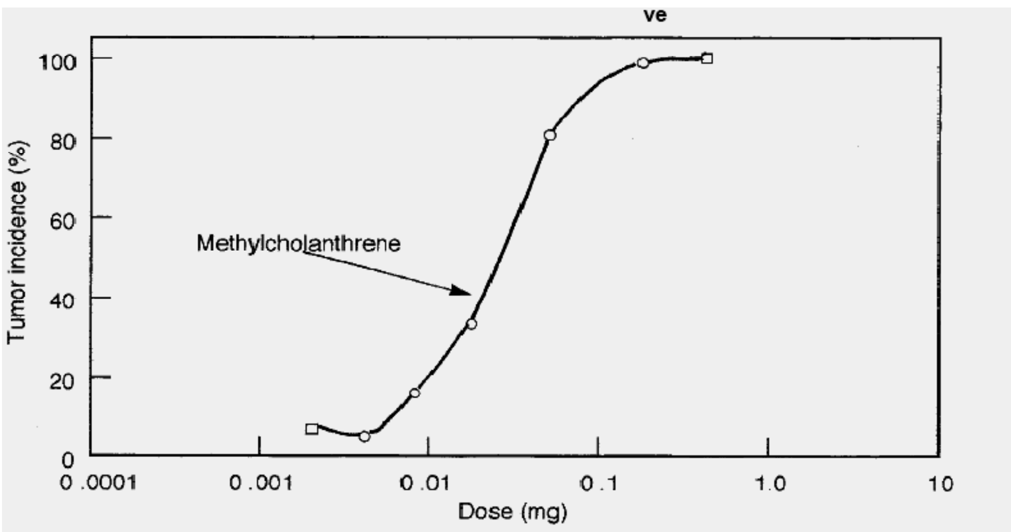

Fig. 3.4: A dose-response curve for a population of mice in astudy of a carcinogenic chemical
Source: Takele and Menghesha (2006)

An important aspect of dose-response relationships is the concept of*threshold*. For most types of toxic responses, there is a dose, calleda threshold, below which there are no adverse effects from exposureto the chemical. The human body has defenses against many toxicagents. Cells in human organs, especially in the liver and kidneys, break down chemicals into nontoxic substances that can beeliminated from the body in urine and feaces. In this way, the humanbody can take some toxic insult (at a dose that is below thethreshold) and still remain healthy.

The identification of the threshold beyond which the human bodycannot remain healthy depends on the type of response that ismeasured and can vary depending on the individual being tested.Thresholds based on acute responses, such as death, are moreeasily determined, while thresholds for chemicals that cause canceror other chronic responses are harder to determine. Even so, it isimportant for toxicologists to identify a level of exposure to achemical at which there is no effect and to determine thresholdswhen possible.

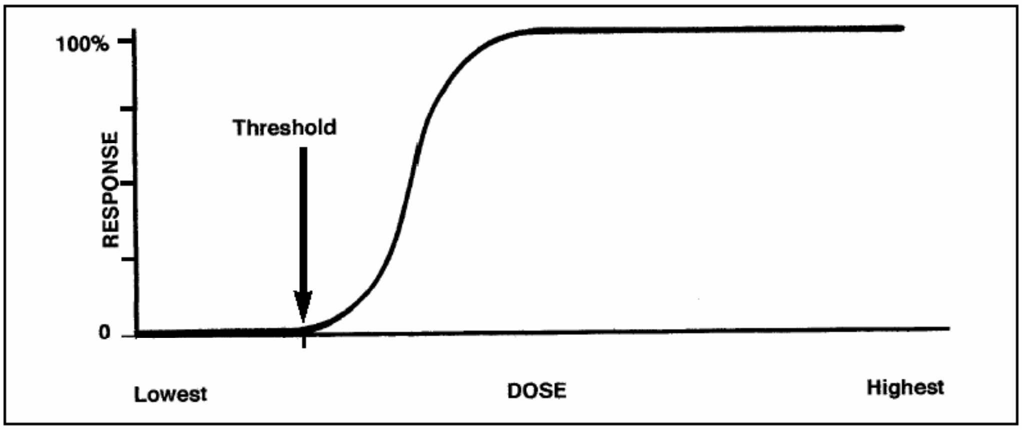

Fig.3.5: Dose-response curves for a chemical agent administeredto a uniform population of test animals
Source: Eaton and Klaassen (1996) in Source: Takele and Menghesha (2006)

When a threshold is difficult to determine, toxicologists look attheslope of the dose-response curve to give them information about thetoxicity of a chemical. A sharp increase in the slope of the curve cansuggest increasingly higher risks of toxic responses as the doseincreases.A comparison of dose-response curves among chemicals can offerinformation about the chemicals as well.A steep curve that begins toclimb even at a small dose suggests a chemical of high potency.The *potency*of a chemical is a measure of its strength as a poisoncompared with other chemicals. The more potent the chemical, theless it takes to kill.

Dose Estimate of Toxic Effects(LD, EC, TD)

Dose-response curves are used to derive dose estimates ofchemical substances. A common dose estimate for acute toxicity isthe LD50 (Lethal Dose 50%). This is a statistically derived dose atwhich 50% of the individuals will be expected to die. Other doseestimates also may be used. LD0 represents the dose at which noindividuals are expected to die. This is just below the threshold forlethality. LD10 refers to the dose at which 10% of the individuals willdie.

For inhalation toxicity, air concentrations are used for exposurevalues. Thus, the LC50 is utilized which stands for *LethalConcentration* 50%, the calculated concentration of a gas lethal to50% of a group. Occasionally LC0 and LC10 are also used.*Effective Doses (EDs)* are used to indicate the effectiveness of asubstance. Normally, effective dose refers to a beneficial effect(relief of pain). It might also stand for a harmful effect (paralysis).*Toxic Doses (TDs)* are utilized to indicate doses that cause adversetoxic effects.The knowledge of the *effective*and *toxic dose*levels aide thetoxicologist and clinician in determining the relative safety ofpharmaceuticals.

Most exposure standards, Threshold Limit Values (TLVs) andPermissible Exposure Limits (PELs), are based on the inhalationroute of exposure. They are normally expressed in terms of eitherparts per million (ppm) or milligrams per cubic meter (mg/m3)concentration in air.If a significant route of exposure for a substance is through skincontact, the MSDS will have a "skin" notation associated with thelisted exposure limit. Examples include: some pesticides, carbondisulfide, phenol, carbon tetrachloride, dioxane, mercury, thalliumcompounds, ethylene, and hydrogen cyanide.

3.4 Health Effects of Toxic Chemicals

Acute poisoning is characterized by rapid absorption of thesubstance and the exposure is sudden and severe. Normally, asingle large exposure is involved. Examples: carbon monoxide orcyanide poisoning.Chronic poisoning is characterized by prolonged or repeatedexposures of a duration measured in days, months or years.Symptoms may not be immediately apparent. Examples: lead ormercury poisoning or pesticide exposure. “Local” refers to the site of action of an agent and means the actiontakes place at the point or area of contact. The site may be skin,mucous membranes, the respiratory tract, gastro-intestinal system, eyes, etc.

Absorption does not necessarily occur. Examples: somestrong acids or alkalis.

"Systemic" refers to a site of action other than the point of contactand presupposes absorption has taken place. For example, aninhaled material may act on the liver. Example: arsenic affects theblood, nervous system, liver, kidneys and skin.Cumulative poisons are characterized by materials that tend to buildup in the body as a result of chronic exposure. The effects are notseen until a critical body burden is reached.Example: heavy metals (such as Lead).Synergistic responses: When two or more hazardous materialexposures occur, the resulting effect can be greater than the effect of the individual exposures. Example: exposure to asbestos andtobacco smoke, producing lung cancer or mesothelioma.

Types of Interactions

There are four basic types of interactions. Each is based on theexpected effects caused by the individual chemicals. The types of interactions are:

1. **Additivity:** is the most common type of interaction. Examples of additivity reactions are:

    - Organophosphate insecticides interfere with nerveconduction. The toxicity of the combination of twoorganophosphate insecticides is equal to the sum ofthe toxicity of each.
    - Chlorinated insecticides and halogenated solventsboth produce liver toxicity. The hepatotoxicity of aninsecticide formulation containing both is equivalentto the sum of the hepatotoxicity of each.

2. **Antagonism:** is often a desirable effect in toxicology and isbasis for most antidotes. Examples include: The samecombination of chemicals produces a different type ofinteraction on the central nervous system. Chlorinatedinsecticides stimulate the central nervous system whereashalogenated solvents cause depression of the nervoussystem. The effect of simultaneous exposure is anantagonistic interaction.

3. **Potentiation**:

    This occurs when a chemical that does not have aspecific toxic effect makes another chemical more toxic. A typical example is the hepatotoxicity of carbon tetrachloride isgreatly enhanced by the presence of isopropanol. Suchexposure may occur in the workplace.

4. **Synergism**: can have serious health effects. Withsynergism, exposure to a chemical may drastically increasethe effect of another chemical. Examples are:

   - Exposure to both cigarette smoke and radon resultsin a significantly greater risk for lung cancer than thesum of the risks of each.
   - The combination of exposure to asbestos andcigarette smoke results in a significantly greater riskfor lung cancer than the sum of the risks of each.

3.5 Factors Influencing Toxicity

Toxicity refers to the extent of the harmful effect a chemical hazard will have on an individual exposed to it. The effect a chemical hazard can have on people exposed to them in the work place is varied. Toxicity depends on some factors which are not the same among people exposed to a chemical hazard. The toxicity of a substance therefore depends on the following:

1. form and innate chemical activity
2. dosage, especially dose-time relationship
3. exposure route
4. species
5. Age
6. Sex
7. ability to be absorbed
8. metabolism
9. distribution within the body
10. excretion
11. presence of other chemicals

3.6 Systemic Toxic Effects and Types

Toxic effects are generally categorized according to the site of thetoxic effect. In some cases, the effect may occur at only one site.This site is referred to as the *specific target organ*. In other cases,toxic effects may occur at multiple sites. This is referred as*systemic toxicity*.Types of systemic toxicity include:

1. Acute Toxicity

Thisoccurs almost immediately (hours/days) after anexposure. An acute exposure is usually a single dose or aseries of doses received within a 24 hour period. Death is amajor concern in cases of acute exposures. Examples are: In1989, 5,000 people died and 30,000 were permanently disableddue to exposure to methyl isocyanate from an industrial accidentin India. Many people die each year from inhaling carbonmonoxide from faulty heaters. Non-lethal acute effects may alsooccur, e.g., convulsions and respiratory irritation.

2. Sub-chronic Toxicity

This results from repeated exposure for severalweeks or months. It is a common human exposure patternfor some pharmaceuticals and environmental agents. Examplesare: Ingestion of coumadin tablets (blood thinners) for severalweeks as a treatment for venous thrombosis which can cause internalbleeding. Workplace exposure to lead over a period of severalweeks can also result in anemia.

3. Chronic Toxicity

Thisrepresents cumulative damage to specific organ systems and takes many months or years to become a recognizableclinical disease. Damage due to subclinical individual exposuresmay go unnoticed. With repeated exposures or long-term continualexposure, the damage from these subclinical exposures slowlybuilds-up (cumulative damage) until the damage exceeds thethreshold for chronic toxicity. Ultimately, the damage becomes sosevere that the organ can no longer function normally and a varietyof chronic toxic effects may result. Examples of chronic toxic effects are:

- cirrhosis in alcoholics who have ingested ethanol forseveral years
- chronic kidney disease in workmen with several yearsexposure to lead
- chronic bronchitis in long-term cigarette smokers
- pulmonary fibrosis in coal miners (black lung disease)

4. Carcinogenicity

This is a complex multi-stage process of abnormal cellgrowth and differentiation which can lead to cancer. At least twostages are recognized. They are initiation in which a normal cellundergoes irreversible changes and promotion in which initiatedcells are stimulated to progress to cancer. Chemicals can act asinitiators or promoters.The initial neoplastic transformation results from the mutation ofthe cellular genes that control normal cell functions.

Themutation may lead to abnormal cell growth. It may involve lossof suppresser genes that usually restrict abnormal cell growth.

Many other factors are involved (e.g., growth factors, immunesuppression, and hormones).A tumor (neoplasm) is simply an uncontrolled growth of cells.Benign tumors grow at the site of origin; do not invade adjacenttissues or metastasize; and generally are treatable. Malignanttumors (cancer) invade adjacent tissues or migrate to distantsites (metastasis). They are more difficult to treat and oftencause death.

5. Developmental Toxicity

This pertains to adverse toxic effects to thedeveloping embryo or fetus. This can result from toxicant exposureto either parent before conception or to the mother and herdeveloping embryo-fetus.

6. Genetic Toxicity (somatic cells)

Chemicals cause developmental toxicity by two methods. They canact directly on cells of the embryo causing cell death or cell damage,leading to abnormal organ development. A chemical might alsoinduce a mutation in a parent's germ cell which is transmitted to thefertilized ovum. Some mutated fertilized ova develop into abnormal embryos.

Genetic toxicity results from damage to DNA and altered geneticexpression. This process is known as mutagenesis. The geneticchange is referred to as a mutation and the agent causing thechange as a mutagen. There are three types of genetic changes:

If the mutation occurs in a germ cell the effect is heritable. There isno effect on the exposed person; rather the effect is passed on tofuture generations. If the mutation occurs in a somaticcell, it cancause altered cell growth (e.g. cancer) or cell death (e.g.teratogenesis) in the exposed person.

Types of organ specific toxic effects are:

- **Blood and Cardiovascular Toxicity**

  This results from xenobiotics actingdirectly on cells in circulating blood, bone marrow, and heart.Examples of blood and cardiovascular toxicity are:

  1. hypoxia due to carbon monoxide binding of hemoglobinpreventing transport of oxygen
  2. decrease in circulating leukocytes due to chloramphenicoldamage to bone marrow cells
  3. leukemia due to benzene damage of bone marrow cells

- **Dermal Toxicity**

  This may result from direct contact or internaldistribution to the skin. Effects range from mild irritation to severechanges, such as corrosivity, hypersensitivity, and skin cancer.Examples of dermal toxicity are:

  1. Dermal irritation due to skin exposure to gasoline
  2. Dermal corrosion due to skin exposure to sodium hydroxide(lye)
  3. Skin cancer due to ingestion of arsenic or skin exposure toUltra violet light

- **Eye Toxicity**

  This results from direct contact or internal distribution to theeye. The cornea and conjunctiva are directly exposed to toxicants.Thus, conjunctivitis and corneal erosion may be observed followingoccupational exposure to chemicals. Many household items cancause conjunctivitis. Chemicals in the circulatory system candistribute to the eye and cause corneal opacity, cataracts, retinaland optic nerve damage.

  For example:

  1. Acids and strong alkalis may cause severe corneal corrosion
  2. Corticosteroids may cause cataracts
  3. Methanol (wood alcohol) may damage the optic nerve

- **Hepatotoxicity**

  This refers to toxicity to the liver, bile duct, and gall bladder.The liver is particularly susceptible to xenobiotics due to a largeblood supply and its role in metabolism. Thus it is exposed to highdoses of the toxicant or its toxic metabolites.

- **Immunotoxicity**

  This is toxicity of the immune system. It can takeseveral forms: hypersensitivity (allergy and autoimmunity), immune deficiency, and uncontrolled proliferation (leukemia andlymphoma). The normal function of the immune system is torecognize and defend against foreign invaders. This isaccomplished by production of cells that engulf and destroy theinvaders or by antibodies that inactivate foreign material.

- **Nephrotoxicity**

  This is the effect of toxic chemicals on the kidney. The kidney is highly susceptible to toxicants for tworeasons. A high volume of blood flows through it and it filtrates and secondly, the largeamounts of toxins which can concentrate in the kidney tubules.

Nephrotoxicity can result in systemictoxicity causing:

1. decreased ability to excrete body wastes
2. inability to maintain body fluid and electrolyte balance

- **Neurotoxicity**

  Neurotoxicity represents toxicant damage to cells of the centralnervous system (brain and spinal cord) and the peripheral nervoussystem (nerves outside the CNS). The primary types of neurotoxicity are:

  1. neuronopathies (neuron injury)
  2. axonopathies (axon injury)
  3. demyelination (loss of axon insulation)
  4. interference with neurotransmission

- **Reproductive Toxicity**

  This involves toxicant damage to either the maleor female reproductive system. Toxic effects may cause:

  1. Infertility
  2. interrupted pregnancy (abortion, fetal death, or prematuredelivery)
  3. infant death or childhood morbidity
  4. chromosome abnormalities and birth defects
  5. childhood cancer

- **Respiratory Toxicity**

  This relates to effects on the upper respiratorysystem (nose, pharynx, larynx, and trachea) and the lowerrespiratory system (bronchi, bronchioles, lung and alveoli). Theprimary types of respiratory toxicity are:

  1. pulmonary irritation
  2. asthma/bronchitis
  3. reactive airway disease
  4. emphysema
  5. allergic alveolitis
  6. Pneumoconiosis
  7. lung cancer

3.7 First Aid Actions for Toxic Chemicals

Emergency care refers to immediate response to exposure to toxic chemicals in an harmful manner. The essence of emergency care is not to treat but to reduce pain and reduce likelihood of the situation getting worse before medical attention is sought. Basic emergency care for exposures to toxic hazards are summarized in the table below.

Exposure	Emergency Care
Eye: Irrigate immediately	If the chemical contacts the eyes, immediatelywash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contactlenses should not be worn when working withthis chemical.
Skin: Blot/brush away	If irritation occurs, gently blot or brush away excess.
Skin: Molten flush immediately/solid-liquid soap wash immediately	If this molten chemical contacts the skin, immediately flush the skin with large amountsof water. Get medical attention immediately. Ifthis chemical (or liquids containing thischemical) contacts the skin, promptly wash thecontaminated skin with soap and water. If this chemical or liquids containing this chemicalpenetrate the clothing, immediately remove the clothing and wash the skin with soap andwater. If irritation persists after washing, get medical attention
Skin: Soap flush Immediately	If this chemical contacts the skin, immediatelyflush the contaminated skin with soap and water. If this chemical penetrates the clothing, immediately remove the clothing and flush theskin with water. If irritation persists afterwashing, get medical attention.
Breath: Respiratory support	If a person breathes large amounts of thischemical, move the exposed person to freshair at once. If breathing has stopped, performmouth-to-mouth resuscitation. Keep theaffected person warm and at rest. Get medicalattention as soon as possible.
Breath: Fresh air	If a person breathes large amounts of thischemical, move the exposed person to freshair at once. Other measures are usually unnecessary.
Swallow: Medical attention immediately	If this chemical has been swallowed, get medical attention immediately

4.0 CONCLUSION

Toxic chemicals are present in almost every industrial setting. It is important to understand how these chemicals get into the human system so as to know how to avoid or prevent them. It is equally important to understand how these toxins affect the body so as to take necessary action if there is an exposure. The focus of this module was therefore on toxic chemicals in the work place and the interaction they have with the human system.

5.0 SUMMARY

- Toxicology is the scientific study of the interaction of industrial chemicals (toxic chemicals) with the human system and biology. Toxic chemicals in the work place cover a broad range including mineral inorganic chemicals, metals and organic chemicals. Just as the name implies, these chemicals are toxic to human system and therefore cause health problems.
- The portal for entry for these toxic chemicals including inhalation (involving breathing them in through contaminated air), skin absorption, ingestion (involving swallowing of these chemicals by accident) and injection (involving entry into the blood stream. This is however very rare in the industrial setting).
- In occupational health, it is important to conduct dose-response assessment. The dose-response is the relationship between exposure and health effect that can be established by measuring the response relative to an increasing dose. This relationship is crucial in estimating the toxicity of a chemical toxin. It is based on the notion that a dose, or a time of exposure to any toxic substance will cause an effect on the organism exposed to such toxic substance.
- The effect of toxic exposure is generally poisoning which is known as toxicity. Toxicity is dependent on a number of factors including dosage, route of exposure, specie of chemical involved, age of the person exposed, sex of the person exposed, excretion, and presence of other chemical substances.
- toxicity can affect a particular organ (specific target organ toxicity) or multiple sites/organs (systemic toxicity).
- Organ specific effects are seen on the blood, skin, liver, eye, kidney, immune system, reproductive system and respiratory system

6.0 TUTOR-MARKED ASSIGNMENT

1. Define toxicology as it applies to the work environment
2. Identify and briefly discuss at least three entry points in the human body for chemical hazards
3. State at least seven factors influencing the toxicity of a chemical substance
4. State emergency care for at least three portal of entry for chemical hazards.

Answers to Assignment

Toxicology

Toxicology is defined as the study of harmful interactions between chemicals and the human biological system. It deals with the way human system, specifically, react or interact with chemical substances that they are exposed to.

Portal of Entry of Toxic Chemicals

- inhalation
- skin absorption
- ingestion
- injection

Inhalation

Just as the name implies, this involves inhaling toxic chemicals through the nasal cavity. It is mainly through contaminated air. Toxic chemicals that enter into the system through this portal are borne in the air. They also bring about respiratory diseases affecting the respiratory system and associated organs and tissues.

Skin Absorption

This involves entry through the skin. In most industrial set-up, protective gowns and clothing are worn in order to prevent contact of toxic chemicals with the skin.

Ingestion

This involves swallowing of toxic chemicals accidentally. Ingestion mainly occurs when industrial workers fail to observe food and hand hygiene. This way, they accidentally ingest toxic chemicals resulting in poisoning.

Factors Influencing Toxicity of Chemical Substance

1. Dosage, especially dose-time relationship
2. Exposure route
3. Species
4. Age
5. Sex

6. ability to be absorbed
7. Metabolism
8. Distribution within the body
9. Excretion

Emergency Care Exposures to Toxic Chemicals

Exposure	Emergency Care
Eye: Irrigate immediately	If the chemical contacts the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.
Skin: Blot/brush away	If irritation occurs, gently blot or brush away excess.
Skin: Molten flush immediately/solid-liquid soap wash immediately	If this molten chemical contacts the skin, immediately flush the skin with large amounts of water. Get medical attention immediately. If this chemical (or liquids containing this chemical) contacts the skin, promptly wash the contaminated skin with soap and water. If thischemical or liquids containing this chemical penetrate the clothing, immediately remove the clothing and wash the skin with soap andwater. If irritation persists after washing, get medical attention
Skin: Soap flush Immediately	If this chemical contacts the skin, immediately flush the contaminated skin with soap andwater. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention.
Breath: Respiratory support	If a person breathes large amounts of thischemical, move the exposed person to freshair at once. If breathing has stopped, perform mouth-to-mouth resuscitation. Keep theaffected person warm and at rest. Get medicalattention as soon as possible.
Breath: Fresh air	If a person breathes large amounts of this chemical, move the exposed person to freshair at once. Other measures are usuallyunnecessary.
Swallow: Medical attention immediately	If this chemical has been swallowed, get medical attention immediately

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MODULE 6 EPIDEMIOLOGY OF OCCUPATIONAL DISEASES AND HEALTH PROBLEMS

CONTENTS

1.0 INTRODUCTION

Recognizing occupational health problems and disorders is important in preventing and managing them. This module focuses on occupational health problems from the point of the organ/system that can be affected. An important part of the module is on determinants of occupational disorders and diseases which provides valuable information on modifiable and non-modifiable factors associated with occupational health problems. Evaluating disorders is also important in managing these disorders. As such, the module also covers practical steps involved in evaluation of occupational disabilities.

2.0 OBJECTIVES

At the end of this module, you should be able to:

- What is Epidemiology in occupational health

- Identify occupational health disorders associated with at least 4 systems and 4 organs in humans
- State at least 10 determinants of occupational disorders
- State occupational disability evaluation steps

3.0 MAIN CONTENT

3.1 Epidemiology of Occupational Health Diseases

Epidemiology deals with the study of the distribution and determinants of health problems in a population with a view to controlling the identified problems. Occupational health and safety at work is an important aspect of public health that requires workers and employers to adhere to safety standards and guidelines important in protecting and enhancing safety of the work environment. The burden of occupational disease and injury is substantial on a global scale. It is conservatively estimated that with well over 1 million deaths a year, nearly 3 percent of the global burden of ill health is directly attributable to occupational conditions (Leigh and others, 1996). This is substantial, accounting for more than motor vehicles, malaria, or HIV and about equal to tuberculosis or stroke.

Globally, studies have shown that occupational health related injuries and deaths are rising. Annually approximately 312,000 fatal unintentional occupational injuries occur (Concha-Barrientos, et al.2005). Another estimate shows that annually about 2 million fatal work-related diseases and occupational accidents occur. Specifically, 345,000 fatal occupational accidents and 1.6 million work-related diseases (Hamalainen, 2007).

Estimate also shows that annually 263 million occupational accidents occur that cause at least four days of absence from work (Mbonigaba, 2015). Recent estimates by WHO (2012) show that about 2.9 billion workers globally are exposed to hazards at their work environment.Whereas occupational health and safety is taken care of as major area of concern to address occupational health related issues in developed countries, the reverse is the case in developing countries like Nigeria (Hollnagel, 2007).

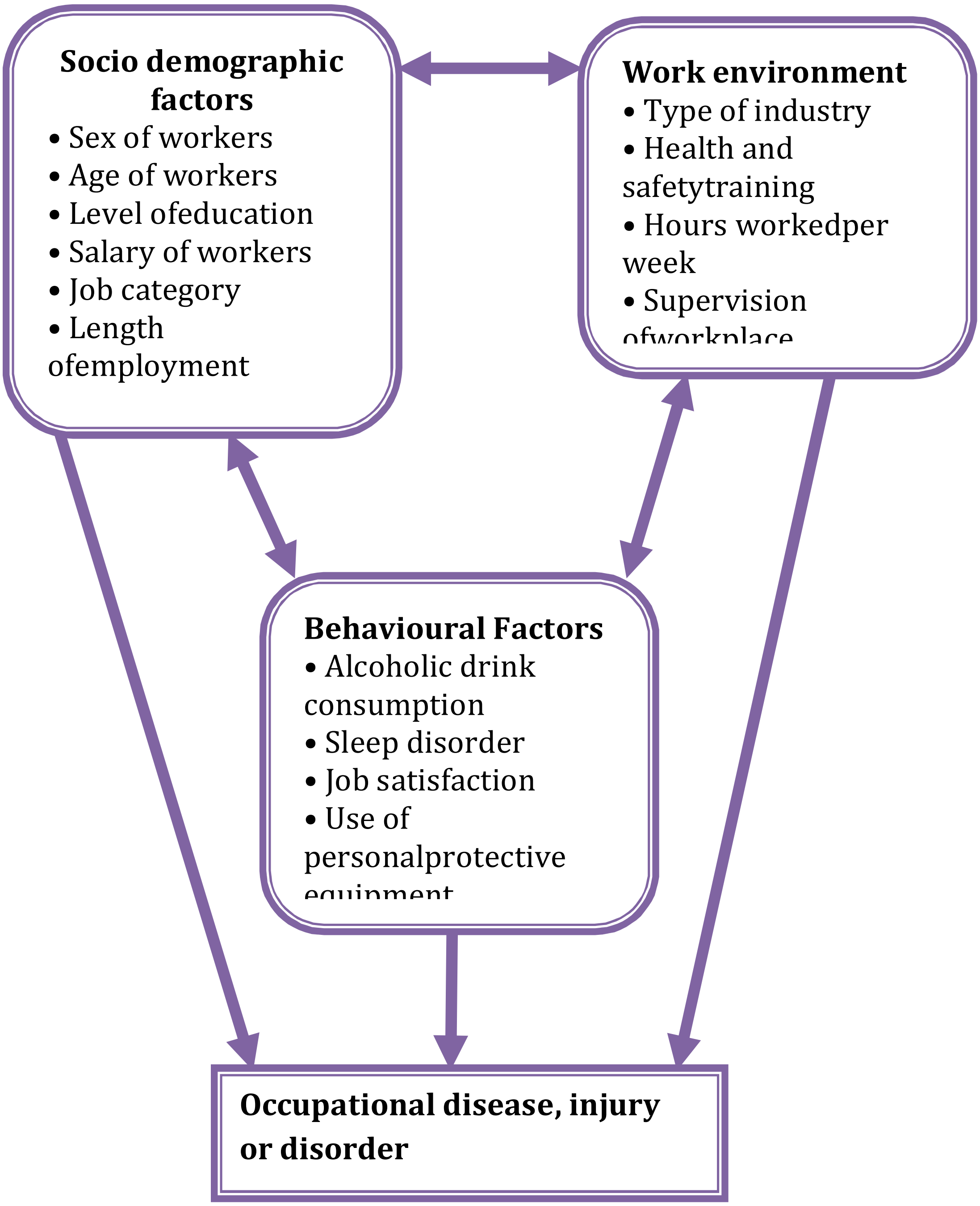
Occupational mortality rates in energy jobs in industrialized countriesare generally 10-30 times lower than in developing countries(Kjellstrom, 1994; ILO, 1998), indicating that more effectiveprevention programme are needed developing countries.

In the early days of the development of employment injuryprotection, attention was concentrated on accidents at work. It wasonly later that protection was widened to include diseasescontracted during work processes. It proved difficult to define thediseases which ought properly to be within the protection of theemployment injury law, while excluding common conditions whichare prevalent among the general population. Usually the national legislation contains a list of diseases which are,beyond dispute, of an occupational origin, at least when they arecontracted by a person who has worked in a process, or in contactwith a substance, which can cause diseases.

In 1925 theInternational Labour Conference was able to agree on only threediseases which could be so prescribed - lead poisoning, mercurypoisoning and anthrax. But research establishes new criteria ofproof, and the accelerating development of industrial chemistry andphysics brings in its train new hazards. Thus, the Employment InjuryBenefits Convention, 1964 (No. 121), contained a list of 15occupational diseases and the list was further revised in 1980 toinclude a total of 29.The next unit gives an overview of determinants of occupational diseases, disorders and injuries.

3.2 Determinants of Occupational Diseases and Injuries

A determinant, according to WHO is a factor that can increase or decrease the likelihood of the occurrence of an adverse health effect like occupational disease or disorder. Determinants of occupational diseases, injuries or disorders are categorized into three as simply described in the model below:



Source: Modified from Takele and Menghesha (2006)

3.3 Occupational Disorders by System/Organ

3.4 Respiratory Disorders

Work-related respiratory disease is frequently a contributory cause andcommonly a primary cause of pulmonary disability. The clinicalevaluation of pulmonary disease includes a minimum of fourelements:

1. a complete history including occupational andenvironmental exposures, a cigarette-smoking history, and a carefulreview of respiratory symptoms;
2. a physical examination withspecial attention to breath sounds;
3. a chest x-ray with appropriateattention to parenchymal and pleural opacities, and
4. pulmonaryfunction tests. Major occupational respiratory diseases are summarized in the table below.

Table 3.3: Major Types of Occupational pulmonary Diseases

Pathophysiologic process	Occupational disease Example	Clinical history/Symptoms
Fibrosis	Silicosis, Asbestosis	Dyspnea on exertion, shortness of breath
Reversible airway obstruction (asthma)	Byssinosis, Isocyanate asthma	Cough, wheeze, chest tightness, shortness of breath, asthma attacks
Emphysema	Cadmium poisoning (chronic)	Cough, sputuma, dyspnea
Granulomas	Beryllium disease	Cough, weight loss, shortness of breath
Pulmonary edema	Smoke inhalation	Frothy, bloody sputum production

3.5 Musculoskeletal Disorders

Work-related musculoskeletal disorders commonly involve the back, cervical spine, and upper extremities. Understanding of these problems has developed rapidly during the past decade. Prevention of a low back pain is a complex challenge. Low back pain prevention in work settings is best accomplished by a combination of measures, such as:

- Job design (ergonomics);
- Job placement (selection);
    - Training and education (training of workers, managers, labour union representatives and health care providers).

Prevention and Control of Musculoskeletal Disorders
Job design (ergonomics)

1. Mechanical aids
2. optimum work level
3. Good workplace layout
4. Sit/stand workstations
5. Appropriate packaging

Job placement (selection)

1. careful history
2. Through physical examination
3. No routine x-ray
4. Strength testing
5. Job-rating programs

Training and Education
Training workers

1. Biomechanics of body movement (safe lifting)
2. Strength and fitness
3. Back to schools

Training managers

1. Response to low back pain
2. Early return to work
3. Ergonomic principles of job design

Training labour union representatives

1. Early return to work
2. Flexible work rules
3. Reasonable referrals

Training health care providers

1. Appropriate medication
2. Prudent use of x-rays
3. Limited bed rest
4. Early return to work (with restrictions, if necessary)

3.6 Skin Disorders

This refers to any cutaneous abnormalities or inflammation caused directly orindirectly by the work environment is an occupational skin disorder.Work-related cutaneous reaction and clinical syndromes are asvaried as the environments in which people work. Skin disorders arethe most frequently reported occupational diseases. About half of all occupational diseases are skin disorders, followed in order by eye disorders, lung disorders, poisoning involving the body as a whole.A basicunderstanding of occupational skin disorders is therefore essentialfor everyone involved in occupational health. Occupational skindiseases are often preventable by a combination of environmental,personal, and medical measures.

3.7 Eye Disorders

In the US where data are available, every working day, there are over 2,000 preventable job-related eye injuries to workers. If this alarming rate can be reported in such a developed country, one can infer what the situation will be in a developing country like Nigeria. Occupational visionprogrammes, including pre-placement examinations and requirements for appropriate eye protectors in certain occupations, can prevent many of these injuries.

Symptoms and signs of serious eye injury

Symptoms of serious eye injury indicating immediate referral are the following:

1. Blurred vision that does not clear with blinking.
2. Loss of all or part of the visual field of an eye
3. Sharp stabbing or deep throbbing pain
4. Double vision

Signs of eye injury that require ophthalmologic evaluation are the following:

1. Black eye
2. Red eye
3. An object on the cornea
4. One eye that does not move as completely as the other
5. One eye protruding forward more than the other
6. One eye with an abnormal pupil size, shape, or reaction to light, as compared to the other eye
7. A layer of blood between the cornea and the iris (hyphema)
8. Laceration of the eyelid, especially if it involves the lid margin.
9. Laceration or perforation of the eye

3.8 Disorders of the Nervous System

The nervous system comprises the brain, spinal cord, and peripheral nerves, is a complex system responsible for both voluntary and involuntary control of most body functions. These are accomplished through a process of receiving and interpreting stimuli as well as transmitting information to the effectors organs. The adverse impacts of stressors from the work environment (physical, chemical, and psychological) are experienced in a variety of ways.

Prevention of Nervous System Disorders

Work-related psychological disorders have been identified as a leading occupational health problem. Prevention strategy focuses mainly on reducing job stress and providing employee mental health services. Efforts to prevent stress-related disorders focus on:

1. ameliorating major areas of job stress;
2. providing job security and career opportunity,
3. providing a supportive social environment,
4. providing meaningful, creative and rewarding work experience;
5. making every effort to ensure worker participation in decision making and
6. control of the work environment.

3.9 Disorders of the Reproductive System

The prevention of reproductive disorders is an important publichealth priority. These problems include abnormalities that affect thereproductive function of both men and women as well as a widerange of unwanted pregnancy outcomes. There are two ways by which occupational specialists can prevent orreduce work-related health risks. The first is through patienteducation and counselling. The second is by intervening in the work place to reduce or eliminate deleterious exposures.

3.10 Disorders of the Cardio-Vascular System

Risk factors associated with CHD can be divided into threecategories: personal, hereditary and environmental. Personal riskfactors include sex, age, race, high serum cholesterol, high bloodpressure, and cigarette smoking. There are strong interactionsbetween these factors that act synergic ally, such that a smoker withhigh blood pressure and high serum cholesterol is eight times moreat risk developing CHD than a non-smoker who has normal serumcholesterol and blood pressure.While the association between personal risk factors and CHD is welldocumented, our knowledge of the role of occupational risk factors isstill limited. Several chemical and physical agents have beensuspected of causing CHD in workers chronically exposed to them. However scientific evidence indicates a direct causal relationship forevery few of them. For most of these agents, the evidence is basedon isolated case reports or on a few unconfirmed studies.

3.11 Hepatic/Liver Disorders

Occupations with exposure to hepatotoxins are found in manydifferent industries including munitions, rubber, cosmetics, perfume,food processing, refrigeration, paint, insecticide and herbicide,pharmaceutical, plastics, and synthetic chemicals. Usually theseworkers are exposed by inhalation of fumes. Most hepatotoxins havepungent odours that warn of their presence, preventing accidentaloral ingestion of large amounts; however, ingestion of imperceptibleamounts of hepatotoxins over long periods of time may cause injury.Skin over long periods of time may cause injury. Skin absorption hasbeen a significant cause of disease only with trinitrotoluene (TNT)exposure in munitions workers and with methylenedianilineexposure in epoxy resin workers.

Common hepatic disorders due to occupational exposures to hepatoxins are summarized in the table below.

Table 3.4: Common Hepatic Disorders

Hepatic Disease	Type of agent	Example of Agent	Susceptible Workers
ACUTE HEPATITIS			
Acute toxic hepatitis	Chlorinated hydrocarbons	Carbon tetrachloride Chloroform	Solventworkers, degreasers,cleaners, refrigerationworkers
	Nitroaromatics	Dinitrophenol (DNP)	Chemical indicator workers
		Dinitrobenzene	Dye workers, explosives workers.
	Ether	Dioxin	Herbicide and insecticide workers
	Halogentaed Aromatics	Polychlorinated biphenyls (PCBs)	Electrical component assemblers
		DDT Chlordecone (kepone)	Insecticide workers, fumigators, disinfectant workers
		Chlorobenzenes	Solvent workers, dye workers

		Halothane	Anesthesiologists
Acute cholestatic hepatitis	Epoxy resin	Methylenedianiline	Rubber workers, epoxy workers, synthetic fabric workers
	Inorganic element	Yellow phosphorus	Pyrotechnics workers
Acute viral hepatitis, type B	Virus	Hepatitis B	Health workers
Subacute hepatic necrosis	Nitroaromatic	TNT	Munitions workers
CHRONIC LIVER DISEASE			
Fibrosis/cirrhosis	Alcohol	Ethyl alcohol	Imbibing bartenders, wine producers, whiskey producers
	Virus	Hepatitis B and C	Day care workers, health care workers Vintners, smelter workers
	Inorganic element	Arsenic	Vinyl chloride workers
	Haloalkene	Vinyl chloride	Vinyl chloride workers
Angiosarcoma	Haloalkene	Vinyl chloride	Rubber workers

3.12 Renal and Urinary Tract Disorders

The kidney is a target organ for a number of toxic chemicalcompounds. Renal excretion is the major route of elimination formany toxic compounds. The relatively high renal blood flow, aboutone-fourth of total cardiac output, exposes the renal structures to arelatively high toxic burden. Concentration of toxins in the glomerularultra-filtrate through active re-absorption contributes further to theintensity of toxic exposures. The considerable endothelial surfacerepresented by the extensive capillary network in the kidney, thepresence in renal tubular cells of numerous important enzymesystems, the local synthesis of active peptides (for example, renninand prostaglandin), and the generally high metabolic rate of theorgan are additional factors increasing the vulnerability of thekidneys to chemical toxins. These agents can adversely affect thedelicate balance between blood flow, glomerular filtration, tubular reabsorption,and filtrate concentration.

3.13 Evaluating Workplace Disability and Compensation System

A clinician's effectiveness in dealing with work ability and disabilityevaluations will be enhanced by a clear understanding of:

1. Keydefinitions related to the evaluation process,
2. Common features ofinsurance plans and anti-discrimination legislation affecting disabledworkers,
3. The clinician's role in the evaluation of work ability, and
4. Unresolved controversies and potential role conflicts for theclinician.

In reviewing the variety of compensation plans and the associatedroles for the health care provider, it is important to recognize a fewkey concepts. Most important is the distinction between impairmentand disability.

*Impairment*is commonly defined as the loss of function of an organor part of the body compared to what previously existed. Ideally,impairment can be defined and described in purely medical termsand quantified in such a way that a reproducible measurement isdeveloped (for example, severe restrictive lung disease with a totallung capacity of 1.6 litres).*Disability*, on the other hand, is usually defined in terms of theimpact of impairment on societal or work functions. A disabilityevaluation would therefore take into account the loss of function(impairment) and the patient's work requirements and homesituation.

Certain agencies use a more restrictive definition ofdisability; for example, the Social Security Administration in the USdefinesdisability as "inability to perform any substantial gainful work." Often,private disability insurance defines disability as an "inability toperform the essential tasks of the usual employment." However, thedetermination of disability is always predicated on an assessment ofimpairment, followed by a determination of the loss in occupationalor societal functioning that result from the impairment. In general,the determination of impairment is performed by a health careprofessional (usually a physician); most often, non-physicianadministrators use this information to determine the presence andextent of disability.

Disability compensation systems frequently request a determinationof the extent and permanence of a disability condition. An injuredworker who cannot do any work because of a medical condition isconsidered to be totally disabled. If this person can work but hassome limitations and cannot do his or her customary work, a partialdisability exists. Either type of disability is considered to betemporary as long as a resolution of the disability is expected. Whenno significant functional improvement is expected, or a condition hasnot changed over a one-year period, it is inferred that a medical endresult(sometimes called maximal medical improvement) has beenachieved. A temporary (partial or total) disability would then beregarded by most systems as a permanent disability.

Workers' compensation insurance systems usually requiredetermination of the work-relatedness of a disability. A work-relatedinjury or disease refers to conditions; however, it may be difficult tobe certain of the relationship of the injury to the workplace is usuallyclear. In chronic conditions, however, it may be difficult to be certainof the relationship between work and disease. It is recommendedthat the physician's determination of work-relatedness should bebased on the evidence of disease, the exposure history, and theepidemiologic evidence linking exposure and disease.

Health professionals must be aware, however, that the legaldefinition of cause may be less exacting than the medical definition,and that most disability systems are based on the legal standard.One legal definition of a work-related condition is one "… arising outof or in the course of employment" or "caused or exacerbated by …employment". Thus, a pre-existing condition, unrelated to work, thatbecomes substantially worse because of work may legally be work-related.A typical legal standard of proof is that a condition is work-relatedif it is "more likely than not" that the condition would not havebeen present or would have been substantially better had the workexposure not occurred.

Disability compensation systems

Some of the confusion regarding disability assessment stems fromthe multitude of disability compensation systems and plan, sinceeach may have its own definition of disability and criteria forassessing impairment. Different countries have designed verifyingapproaches to providing income security to those who find theirwage-earning capacity compromised by injury or disease.Occupational physicians are most familiar with workerscompensation insurance, which provides coverage of most federal,state, and private employees. These plans compensate for medicalexpenses and lost wages due to work-related conditions.

In developed countries, the central government sponsors the major compensation programmesfor the severely disabled, through Social Security DisabilityInsurance. These programmes pay a limited amount of compensationto those who are unable to achieve any gainful employment,regardless of the cause of disability.Private disability insurance is often purchased by individuals orprovided as an employer or union benefit and is designed to providecompensation for those who are unable to work at their regular jobsregardless of the cause of disability, or to supplement SocialSecurity benefits.Thus, a patient who can no longer work because of injury or illnessmight receive support from his or her employer's insurer, a federal orstate agency, and /or an insurance policy that has been purchasedprivately.

Features of Disability Compensation Systems

Although each plan has different eligibility criteria and levels ofpayment, all share a few common features:

1. Every plan incorporates shared risk. Many people oremployers at risk of financial losses contribute to a pool,from which a few individuals are reimbursed. The cost ofentering the pool is partially determined by the actuarial riskof future events for that person or insured group. Thus,private disability insurance is much more expensive per yearfor a 55-year-old than for a 20-year-old, since the olderworker has a higher risk of disabling medical illness.Workers' compensation insurance is more expensive peremployee for a construction company (higher risk of injury toemployees) than for a stock brokerage firm.
2. Because payments into the pool are predictable, finiteresources are available to all potential recipients of eachplan. Therefore, eligibility criteria are structured so that thelimited resources go to those in greatest need. Workers'compensation plans often do not replace lost wages forfewer than 6 days of absence from work, since doing somight greatly increase the cost of the programme. Many privatedisability insurance plans do not begin coverage until 30days to 6 months of illness absence has occurred.
3. Before medical evaluation of impairment, a potentialrecipient of benefits must first demonstrate legal eligibility.The basis for eligibility is different in each plan. One musthave worked and contributed to Social Security for 5 of thepast 10 years. Workers' compensation covers only regularemployees, not consultants or sub-contractors. Privatedisability insurance often does not cover illness that occursduring the first 60 to 90 days of enrolment.
4. Medical information on impairment is requested once a legalbasis for a claim has been established. In every system, amedical diagnosis is necessary; in the worker'scompensation system, physicians are often asked theiropinions on the work-relatedness of employees' conditions,the prognosis for eventual return to work, and

therestrictions or job accommodations that might be necessaryto return the worker to employment.

5. The information from the physician, however, does notdetermine whether benefits are awarded or how much ispaid; all of these systems are under administrative control.In the Social Security system, an administrator-physicianteam reviews medical information from the evaluatingphysician and compares it with specific criteria for eligibility.In the worker's compensation systems, if there is asignificant discrepancy between the employer's report of aninjury and the physician's report, benefits may be withheldpending an investigation by the insurance company.
6. Benefits are limited and are intended to provide only aproportion of lost wages, medical expenses related to thespecific impairment, and vocational rehabilitation. Only inrare circumstances are worker's compensation benefitsintended to punish gross negligence by an employer incausing the injury; in all other instances, fault has no bearingon benefit levels.
7. Applicants generally have a right of appeal of anadministrative or medical decision, with review by a thirdparty. In the Social Security system, applicants who areinitially denied benefits can appeal to a secondadministrator-physician team, then to an administrative lawjudge, and finally to the federal courts, if desired. In mostworker's compensation plans, the claimant can request anadministrative hearing and be represented by an attorney.The agencies that provide benefits also conduct periodicreviews of cases to verify that continued eligibility (disability)exists.
8. Recently, there has been an increased emphasis ondeveloping resources for retraining and rehabilitation,closely allied with each system. Beneficiaries are oftenrequired to participate in programmes to maximize theirpotential for return to alternative, gainful employment.The purpose of each plan is to reimburse workers for medicalexpenses, rehabilitation expenses, and lost wages that result from awork-related injury or illness. Plans are generally designed to benon-adversarial so that, in most cases, limited benefits are paid toinjured workers without the necessity of a formal hearing. In mostcases of acute traumatic injuries (for example, fractures orlacerations occurring at work), the relationship to work isunquestionable and the system works reasonably well atcompensating the injured worker.

In many cases, however, therelationship to work is less clear, and the demand on the clinicianmore complicated.With regard to causality, the high prevalence of non-specific lowback pain in the general population and the multi-factional etiology ofthis common condition make it impossible to say with medical certainty that this patient's back discomfort was caused in its entiretyby his work. Several epidemiologic studies, however, have linkedtruck driving with a higher incidence of chronic disabling low backpain and have attributed this increase to excessive vibration, sitting, and heavy lifting. Despite medical uncertainty, it is likely that mostcompensation systems would recognize this patient's low back painas a condition that is aggravated by work and that the patient'smedical bills and lost wages related to his back pain would beconverted by workers' compensation insurance.

If for instance, a patient with severe chronic lung disease was being evaluated fordisability under Social Security. His exposure history was significantfor occupational exposure to asbestos and non-occupationalexposure to cigarette smoke. His physical examination, chest x-ray, and pulmonary function tests were consistent with diagnoses of (1) severe obstructive lung disease and possible restrictive lungdisease, and (2) asbestos-related pleural plaques.The patient's occupational exposure to asbestos might have playeda small etiologic role in the development of pulmonary insufficiency.

Steps in the Disability Evaluation Process

The following questions are involved in disability evaluation:

1. What is the patient's medical diagnosis?
2. Does the individual have any impairment is present, is ittemporary or permanent?
3. What is the extent of any impairment?
4. Is the patient's impairment or disease caused or aggravatedbywork?
5. What is the impact of this impairment on the individual'sability to obtain employment in specific occupations and toperform specific jobs? Might accommodations allow foremployment?
6. What other sources of information on work capabilities orpossible accommodations should be considered?
7. In consideration of the answers to the previous questions, towhat, if any, economic benefit is the individual entitled?

4.0 CONCLUSION

Preventing and controlling occupational health disorders begins with a clear understanding of the kind and nature of disorders that threaten workers health and safety as well as determinants of susceptibility and toxicity. This module undertook epidemiology of occupational health disorders beginning with a global outlook of incidence and prevalence with special focus on developing countries like Nigeria. Determinants of susceptibility and level of toxicity among workers were also covered as well as disorders peculiar to different organs and systems in humans. The module also attempted how to evaluate disability arising from the work environment.

5.0 SUMMARY

- On a general note, Epidemiology deals with the study of the distribution and determinants of health problems in a population with a view to controlling the identified problems.
- When related to occupational health, it involves distribution and determinants of occupational health disorders.
- Every work setting predispose workers to health problems and the risk of manifestation as well as severity of these hazards are determined by certain factors.
- These factors are known as determinants of occupational health disorders. They are broadly categorized into three: socio-demographic (e.g. age, sex, location etc.); work environment (type of industry, health and safety training and hours worked per week) and behavioural variable (e.g. alcohol consumption).

6.0 TUTOR-MARKED ASSIGNMENT

1. What is Epidemiology in occupational health?
2. Identify occupational health disorders, one each, associated with at least 4 systems and organs in humans
3. State at least 7 determinants of occupational disorders

Solution

Epidemiology in Occupational Health

This is the study of the distribution and determinants of occupational health disorders.

Health Disorders and their Organ/System

Organ/System	**Disorder**
Eye	Blurred vision Double vision
Skin	Skin cancer
Respiratory System	Silicosis Asbestosis
Reproductive System	Congenital malformation
Liver	Acute toxic hepatitis
Renal/Urinary System	Kidney malfunction

Ten Determinants of Occupational Health Disorders

1. age
2. sex
3. nature of industry
4. safety training
5. location of industry
6. work experience
7. lifestyle like alcohol consumption

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MODULE 7 EVALUATION OF OCCUPATIONAL DISORDERS AND SAFETY

CONTENTS

1.0 INTRODUCTION

Beyond identifying occupational health problems and disorders, it is important to evaluate them in order to make informed decision regarding reducing their occurrence. This module is centered on evaluating the working environment as regards health hazards and threats in order to make well informed decision on conditioning the work environment to protect and promote workers health and safety.

2.0 OBJECTIVES

At the end of this module, you should be able to:

1. Define evaluation in relation to occupational health and safety
2. Define health surveillance
3. State and explain methods involved in biological measurements in health surveillance
4. Mention three ways of measuring occupational health hazards

3.0 MAIN CONTENTS

3.1 Meaning of Evaluation in Relation to Occupational Healthand Safety

Occupational health evaluation can be defined as the decision making process based on measurement of the degree of risk arising from exposure tochemical, physical, biological, or other agents in the work environment. It also involvesmaking a judgment of the magnitude of these agents and determines the levels of contaminants arising from a process orwork operation and the effectiveness of any control measures used. Evaluation in occupational health is concerned with the assessment of the work environment for decision making onconditioning the working environment toobtain maximum satisfaction in productivity, and workers' health,safety and well-being.

The recognition and subsequent identificationof the specific contaminants (dust, fume, gas, vapor, mist, micro-organisms, and sound pressure level etc) is the first stage inthe sequence. A number of spot check devices are used such asdetector stain tubes for gases, or in the case of noise, a soundpressure meter.Once the contaminants have been identified, it is necessary tomeasure the extent of the contamination. Evaluation is an importantpart of the procedure for measurement. Measured level ofcontamination must be compared with existing hygiene standards(always assuming there is such a standard applicable to the materialin question), such as exposure limits, control limits andrecommended limits. In addition, the duration and frequency ofexposure to the contaminants must be taken into account. Followinga comprehensive evaluation, a decision must be made as to theactual degree of risk to workers involved. This degree of risk willdetermine the effective control strategy to be applied.

3.2 Air Sampling/Assessment in Occupational Health Evaluation

Air is a very important and basic necessity for survival at every point of reference including the work environment. It is therefore important to frequently measure air quality so as to monitor and ensure that it is not hazardous to workers.

Method of Air Quality Sampling and Assessment

There are two methods employed in assessing air quality in the work environment. They are grab sampling and integrated sampling methods.Difference in the two methods lies in duration depending on the kind of information needed. The methods are briefly described below:

Grab Sampling Method

This is the collection of an air sample over a short period. It is also known as instantaneous sampling method. Grab samplesrepresent the environmental concentration at aparticular point in time. It is ideal for following cyclic processand for determining air- borne concentration of brief durationbut it is seldom used to estimate eight-hour averageconcentration.

Integrated Sampling Method

This is the sampling of air for a longer period of time. In integrated sampling, a known volume of air is passedthrough a collection media to remove the contaminant from thesampled air stream.

3.3 Work Environment and Worker Assessment

Aside air quality assessment, it is equally important to assess the working environment other than air and the worker himself.

Environmental/Area Sampling or Assessment

Environmental sampling includes sampling for gases, vapors,aerosol concentrations, noise, temperature etc. Which are found onthe worker or the general work area or environment.Area or general room air samplings are taken at fixed locations inthe work place. This type of sampling does not provide a goodestimate of worker exposure. For this reason it is used mainly to pinpoint high exposure areas, indicate flammable or explosive concentrations, or determine if an area should be isolated orrestricted to prevent employees from entering a highly contaminatedarea.

Personal/Worker Sampling or Assessment

The objective of personal sampling is to see the extent of exposure of the person working on a particular contaminant while he/she is working at a location or work place. For example, if the worker is working in a garage where cars are painted the area as a whole is sampled to see how much lead which is present in all car paints, is on the air but with personal sampling one can determine how much are inhaled by the person performing the work or those who are working nearby. In short it is the preferred method of evaluating workers exposure to air contaminants.

3.4 Health Surveillance and Biological Measurement

Health surveillance is concerned with assessment of the working environment and the worker and keeping complete record of the outcomes of these assessments for reference and monitoring. In case of exposure and hazard manifestations, it is important to keep records of what happened and monitor the condition of the person and event. Important biological measurements that are needed in health surveillance include:

- Medical tests e.g.
    - Kidney function tests,
    - Lung function tests,
    - Chest x-rays, etc.

- Biological Sampling

  Biological sampling provides us with different information than airsampling. It indicates exactly what has been absorbed into the bodyrather than what is in the environment. Biological Sampling can bedefined as the measurement of a substance or it's metabolites inbody tissues or fluids in order to assess the working environment or the riskto exposed workers.

3.5 Measurement of Occupational Hazards

3.5.1 Particulate Matter Measurement

In order to measure dust exposure, it is necessary to determine thecomposition of dust that are suspended in the air where workersbreathe. Operation that involves the crushing, grinding, or polishingof minerals or mineral mixtures frequently do not produce air-bornedusts that have the same size composition.When air samples are collected in the immediate vicinity of dustproducing operation, larger particles that have not yet had time tosettle from the air may be collected. If a larger number of theseparticles appear in the dust sample, the effect of their presence mayhave to be evaluated separately.To evaluate either the relative hazard to health posed by dusts oreffectiveness of dust control measures, one must have a method ofdetermining the extent of the dust problem.

Ideally the methodemployed should be as closely related to the health hazard aspossible. The basic methods are briefly discussed below:

1. ***Count Procedure***

   The concern of industrial hygienists has been to measure thefraction of dust that can cause pneumoconiosis. Since it has beenrecognized that only dust particle smaller than approximately 10micrometer are deposited and retained in the lung method weresought to measure the concentration of these tiny particles.Microscopic counting of dust collected has long been used for thispurpose.

2. ***" Total" Mass Concentration Method***

   The simplest method of measuring dust concentration is todetermine the total weight of dust collected in a given volume of air.The "total" mass, however, is determined to a considerable extent bythe large dust particle, which cannot penetrate to the pulmonaryspace and cause adverse health effect. Thus the total dustconcentration by weight is not a reliable index of "respirable" dustconcentration. This is because in this method of measurement theproportion of dust that is small enough to penetrate into thepulmonary space (respirable dust 2.5-micrometer) is extremelyvariable ranging from 5 percent to 60 percent.

3. ***Respirable Mass Size Selection Measurement (Personal Sampling)***

   When measuring respirable dust, the method now commonly used ispersonal or breathing zone respirable mass sampling. Dustcollection devices now available for this method of sampling alsoprovide a means for a size frequency analysis of the collected dust.

Respirable mass samples are preferably taken over a full 8 hourshift. However, multiple, shorter period samples (over a 2-4 hourperiod) may be collected during an individual full shift period.In general, any dust particle producing activity will have respirabledust. For example road construction, cotton ginning, stone crushingand milling site, farm sites etc all produce same amount of dust. Bypractice 30-40% of dust are respirable. Even if the particle size cannot be measured, it can be ascertained through the mass producedin a certain work site that the worker is exposed to respirable dustparticle.

Air sampling instruments

The sampling instruments are geared to the type of air contaminantsthat occur in the work place that will depend upon the new materialsused and the processes employed.

Air contamination can be divided into two broad groups dependingupon physical characteristics.

- Gases and vapors
- Particulate

3.5.2 Noise Evaluation

The purposes of a detailed noise assessment are:

1. To obtain specific information on the noise levels existing ateach employee work station
2. To develop guidelines for establishing engineering and/oradministrative controls.
3. To define areaswhere hearing protection will be required.
4. To determine those work areas where audiometric testing ofemployees is desirable and/or required.

Conducting noise evaluation will be helpful in providing healthful work environment as it helps to determine:

- Whether noise problems exist or not;
- How noisy is created in each work place or station,
- What equipment or process is producing the noise,
- Which employees are exposed to the noise often,
- Duration of exposure to the noise, etc.

Therefore, for evaluation purposes noise measurement is conductedusing such strategy such as:

1. Measuring noise levels using area measurement methods
2. Work station measurement

Sound measurement in the industrial setting falls into two broad categories.

1. Source measurement
2. Ambient-noise measurement

Source measurement involves the collection of acoustical data forthe purpose of determining the characteristics of noise radiated by asource. On the other hand, ambient noise measurement ranges from studying a single soundlevel to making a detailed analysis showing hundreds of componentsof complex variations.

Because of the fluctuating nature of many industrial noise levels, itwould not be accurate or meaningful to use a single sound levelmeter reading. For this reason a preliminary and a detailed noisesurvey has to be conducted in the industry.

There are various equipment available for noise measurement. Some of these instruments are:

1. Sound Survey meter/Sound level meter/
2. Octave band analyzers
3. Narrow band analyzers
4. Tape and graphic level recorders
5. Impact sound level meters
6. Dosimeter

For most noise problems encountered in industries, the sound levelmeter and octave band analyzer, and if available noise dosimeterprovide ample information.

Sound level Meter/Sound survey meter

This is one of the basic instruments used to measure soundpressure variations in air. This instrument contains a microphone,an amplifier with a calibrated attenuator, a set of frequency responsenetworks, and an indicating meter. It is an electronic voltmeter thatmeasures the electrical signal emitted from a microphone attachedto the instrument. Exposure duration at workstation where theregular noise levels varies above 85 dBA.

3.5.3 Evaluating Thermal Environment/Heat Stress

Heat stress is a real challenge as there is not only one but fourenvironmental parameters which must be considered. The extent ofstress suffered depends on:

- **Air temperature**:
  This is widely known as room temperature. At its simplest, it could be measuredusing ordinarymercury in glass thermometer.

Radiant Temperature:

This is measured by using a globethermometer. This consists of a hollow copper sphere measuringabout 15cm in diameter, and painted black. A mercury-in-glassthermometer is inserted into the sphere to a point such that the bulbof the thermometer is at its center. Radiant heat is absorbed by thesphere, which indicates a higher reading.

Humidity:
The classical instrument for determining humidity is the whirlinghygrometer. It contains two thermometers side by side. The bulb ofone thermometer is covered with a wetted fabric, whereas that of theother is left dry. As the instrument is whirled, the water evaporatesfrom the fabric and the evaporative effect cools the thermometerbulb referred to as the wet-bulb thermometer. The wet bulb readingis usually lower than the dry bulb reading. The differences betweenthese two thermometers depend upon the amount of moisturealready in the air. The greater the difference between thethermometers the drier the air and the greater the potential to cooldown through sweating.

Air movement
This is commonly measured with hot wire anemometers and vaneanemometers. The older but still very accurate instrument is the katathermometer. The Kata thermometeris an alcohol filled thermometer with a largebulb coated with silvery material. When used, the bulb is heated inwarm water until the alcohol rises into the upper reservoir. Then thebulb is dried with a clean dry cloth and suspended in the air. Thetime the alcohol takes to fall from the upper limit to the lower limit onthe stem is timed using a stopwatch. From the cooling time, the drybulbtemperature and the kata factor, which is usually printed on the stem, air speed can be read from the monogram provided with theinstrument.

Illumuinance
Use photocells based upon silicon or selenium and they alsoincorporate colour-correcting filters to match the sensitivity of thehuman eye. The photocell also needs to be cosine corrected. Without this, light arriving at glancing angles is underestimated.

4.0 CONCLUSION

Occupational health hazards need to be measured in relation to their potential health effects on workers. Prevention and control information must be based on empirical assessment of the study of the work environment in order to design responsive strategies that will take cognizance of the realities in the work environment. Evaluation of occupational health hazards provides the needed insight to make informed decision on meaningful prevention and control measures. There is also the overwhelming importance of surveillance especially in cases where hazards have manifested. Surveillance entails close monitoring of events and person involved in the hazard through appropriate reporting, record keeping and use of collected information.

5.0 SUMMARY

The module summary centres on:

- Evaluation of occupational hazard as a cornerstone in preventing and controlling occupational hazard.
- Health surveillance through reporting and record keeping as vital evaluation procedures.
- Evaluation is done through particulate measurement, evaluation of noise level and evaluation of thermal stress.

6.0 TUTOR-MARKED ASSIGNMENT

1. Define evaluation in relation to occupational health and safety
2. Define health surveillance
3. State and explain biological methods involved in surveillance
4. Mention three ways of measuring occupational health hazards

Solution

Evaluation in Occupational Health and Safety

This refers to the assessment and measurement of risk and hazard in the work setting with the view to making well-informed preventive and controlling decisions.

Health Surveillance

This refers to close monitoring of a hazardous event or vulnerable persons with a view to preventing and controlling occupational health disorders.

Biological Methods Involved in Surveillance

Two biological methods – medical tests and biological sampling are involved.

1. Medical test refers to medical screening e.g.
   - Kidney function tests,
   - Lung function tests,
   - Chest x-rays, etc.

2. Biological Sampling

   Beyond assessing the air quality in the external environment, this method of surveillance is concerned with assessing hazardous materials that the body has absorbed. It connotes measurement of a substance or it’s metabolites in body tissues or fluids as a means of assessing the working environment or the risk to exposed workers.

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MODULE 8 PREVENTING AND CONTROLLING OCCUPATIONAL DISEASES, INJURIES AND DISORDERS

CONTENTS

1.0 INTRODUCTION

Previous modules focused on identifying and evaluating occupational health problems. Having identified and evaluated these problems, it is important to evolve strategies to reduce their occurrence to the barest minimum. The focus of this module is on preventing and controlling occupational diseases, injuries and disorders.

2.0 OBJECTIVES

At the end of this module, you should be able to:

- Differentiate between prevention and control of occupational diseases and injuries
- Highlight the procedures involved in preventing and controlling occupational diseases
- Design a simple Health Education programme for workers in an identified occupational setting

3.0 MAIN CONTENTS

3.1 Meaning of Prevention and Control of Occupational Diseases

Prevention is the highest and utmost aim of disease control in Epidemiology. It refers to actions and strategies taken to ensure that diseases do not occur at all. When related to work setting, prevention entails strategies and efforts aimed at ensuring that occupational disease, injury and disorder do not occur at all. It might combine many strategies but the aim of the strategies is solely tied to ensuring that disease, disorder or injury does not occur. On the other hand, control has prevention embedded into it as a strategy. In its broadest term disease or injury control describes actions and strategies aimed at reducing the:

- incidence of a disease or injury,
- duration of disease and injury
- risk of transmission, if communicable
- physical and psycho-social effects of disease or injury
- financial burden on an industry due to disease and injury occurrence.

In actual sense, disease and injury control is combination of primary prevention and secondary prevention and in extreme cases, tertiary prevention. Occupational diseases and injuries are, in principle, preventable.Among the approaches to prevent these include, developingawareness of occupational health and safety hazards amongworkers and employers, assessing the nature and extent of hazards, introducing and maintaining effective control and evaluationmeasures. These efforts are carried out by stakeholders including government, employers of labour and workers themselves.

On the part of the government, efforts are largely promulgation of and enforcement of occupational health laws and policies. Government bears the responsibility of ensuring safety regulations for industries operating within its area or country. Since working conditions which might be a reflection of the societal living condition also affect workers' health, provision of social amenities and insudtrial support could also be a way government can help in boisting workers' health and well-being. Takele and Menghesha (2006) thus noted that occupational health programmeshave been developed hand-in-hand with the improvement of socialconditions for underserved and unprivileged workers.

The authors noted that the classic occupational hygiene model of controlling a hazard,indicates that the ideal situation is to prevent exposure altogether.This is known as control at the source and constitutes primary prevention. It utilizes substitution orenclosure of the hazard, as well as other means. When it is impossible to prevent exposure through these approaches, then exposure reduction becomes the most appropriate strategy. In reducing hazard exposure, measures like ventilation, use of protective barriers, or any other related measure could be adopted. Other primary prevention methods include use of personalprotective equipment, administrative controls, safety training and biological measurelike immunization. Early detection and remediation of hazard exposure underly secondary prevention strategies.On the part of the occupational health expert in the industry, efforts aimed at determining the extent of exposure include locating the source of the hazard as well as the pathway through which workers can be exposed to it. These are discussed in details in subsequent section of this course material.

3.2 Hierarchy of Occupational Hazard Prevention and Control Methods

Occupational hzard and prevention and control measures have been generally classified into six:

1. elimination,
2. substitution,
3. engineering controls,
4. administrative controls,
5. use of personal protective equipment and
6. industrial health education (Takele and Menghesha, 2006).

3.2.1 Elimination

Elimination in Epidemiology connotes the interruption on the spread or transmission of a disease or health problem. It precedes eradication and as such, it is vital to realizing the goal of disease or injury eradication. In an industrial setting, eliminating a hazard completely is the ideal solution to occupational health problems although it isnearly difficult to achieve. There are however certain barriers that make elimination nearly impossible. Some identified barriers include:

1. The quality of the potential hazardous product may have a service life of many years,and even a small defect in quality could cause it to fail in use. Thismight lead to liability claims. Sometimes quality

standards may alsohave been set or approved by the customer or a regulatory authority.

2. Applications to change the production method may then be difficultor expensive.
3. The cost of the product may be increased. Raw materials or energycosts may be higher or the production time may be increased if thenew method is slower. It is important to consider workershealth and safety when workprocesses are still in the planning stages. For example, whenpurchasing a machine, safety should be the first concern rather thancost.

It is importat that industrial machines conform to safety standards. These machines mustbe designed with the correct guard on them to eliminate the dangerof a worker getting caught in the machine while using it. Machinesthat are not produced with the proper guards on them may cost lessto purchase, but cost more in terms of accidents, loss of production,compensation, etc. Unfortunately, many machines that do not meetsafety standards are exported to developing countries like Nigeria, causingworkers to pay the price with injuries and mishaps and in some instances, their lives.

3.2.2 Substitution

Substitution invoves replacing a hazardous product or process by a safer or less harzadours one. Substitution, in the agricultural industry could involveusing less hazardous spesticides such as those based on pyrethrins (prepared from naturalproduct), which are considered to be less toxic to humans thansome other pesticides. This particular substitution is practiced insome countries because the substitute chemicals do not leaveresidues on food and therefore reduced long-term costs. Thesubstituted materials may cost more to buy and may cause resistance in insects. So it can be seen that there are many factors to beconsidered when choosing a chemical or chemical substitute.

3.2.3 Engineering Controls

It is not easy to find safer chemical substitute (in fact, no chemicalshould be considered completely safe). It is important to reviewcurrent reports every year on the chemicals used in the work placesso that safe chemicals could be considered for the future.When looking for safer substitute, a less volatile chemical is selectedof a highly volatile one or solid, instead of liquid. Other examples ofsubstitutions include using:

1. Less hazardous instead of toxic ones.
2. Detergent plus water cleaning solutions instead of organicsolvents
3. Using Freon instead of methyl bromide chloride as a refrigerant
4. Leadless glazes in the ceramics industry
5. Leadless pigments in paints
6. Synthetic grinding wheels (such as aluminum oxide, silicon carboide) instead of sandstone wheels.

An engineering control may mean changing a piece of machinery(for example, using proper, machine guards) or a work process toreduce exposure to a hazard; working a limited number of hours in a hazardous area; and there are number of common controlmeasures which are called engineering control. This includesenclosure, isolation and ventilation.

Enclosure

If a hazardous substance or work process cannot be eliminated orsubstituted, then enclosure of the hazard is the next best method ofcontrol. Many hazards can be controlled by partially or totallyenclosing the work process. Highly toxic materials that can bereleased into the air should be totally enclosed, usually by using amechanical handling device or a closed glove system that can beoperated from the outside.The plant can be enclosed and workers could perform their dutiesfrom a control room. Enclosing hazards can minimize possible exposure, but does not eliminate them. For example, maintenanceworkers who serve or repair these enclosed areas can be exposed. To prevent maintenance workers from being exposed,other protective measures (such as protective clothing, respirators,proper training, medical surveillance, etc) must be used as well assafety procedures. Machine guarding is another form of enclosure that prevent workerscoming into contact with dangerous parts of machines. Workersshould receive training on how to use guarded machine safely.

Isolation

Isolation can be an effective method of control if a hazardousmaterial can be moved to a part of work place where fewer peoplewill be exposed, or if a job can be changed to a shift when fewerpeople are exposed (such as weekend or midnight shift). Theworker can also be isolated from hazardous job for example byworking in an air-conditioned control booth.Whether it is the job or the worker that is isolated access to thedangerous work areas should be limited to few people as much aspossible to reduce exposures.

It is also important to limit the lengthof time and the amount of substance(s) to which workers areexposed if they must work in hazardous area. For example, dustproducing work should be isolated from other work areas to preventother worker from being exposed. At the same time, workers in thedusty areas must be protected and restricted to only a short timeworking in those areas. It must however be noted that isolating the work process or the worker does noteliminate the hazard which means workers can still be exposed.

Ventilation

Ventilation in work place can be used for two reasons:

- to preventthe work environment from being too hot, cold, dry or humid
- toprevent contaminants in the air from getting into the area whereworkers breathe.

Generally, there are two categories of ventilation.

1. General or dilution Ventilation
2. Local Exhaust ventilation

General or dilution Ventilation

This adds or removes air from work place to keep the concentrationsof an air contaminant below hazardous level. This system usesnatural convection through open doors or windows, roof ventilatorsand chimneys, or air movement produced by fans or blowers. It is recommended to use the general ventilation system if thefollowing criteria are fulfilled:

1. Small quantities of air contaminants released into the workroomat fairly uniform rate.
2. Sufficient distance between the worker(s) and the contaminantsource to allow sufficient air movement to dilute the contaminantto a safe level.
3. Only contaminant of low toxicity are being used
4. No need to collect or filter the contaminants before exhaust air isdischarged into the community environment.
5. No corrosion or other damage to equipment from the dilutedcontaminants in the workroom area.

Local Exhaust Ventilation

This is considered the classical method ofcontrol for dust, fumes, vapours and other air-borne toxic or gaseouspollutants. The ventilation system captures or contains thecontaminants at their source before they escape into the workroomenvironment. A typical system contains one or more hoods, ducts,air cleaners and a fan. Such systems remove but do not dilute likegeneral exhaust ventilation although removal may not be 100percent complete. This method is very useful especially for thechemical or contaminants that cannot be controlled by substitution,changing the process, isolation or enclosure. One other majoradvantage in such system requires less airflow than dilution ventilation system.

3.2.4 Administrative Control

Administrative controls limit the amounts of time workers spend athazardous job locations. Administrative control can be used togetherwith other methods of control to reduce exposure to occupationalhazards.Some examples of administrative controls include:

1. Changing work schedules, for example two people may be ableto work 4 hours each at a job instead of one person working for8 hours at that job.
2. Giving workers longer rest periods or shorter work shifts in order toreduce exposure time
3. Moving a hazardous work process so that few people will beexposed
4. Changing a work process to a shift when fewer people are working
5. Ensuring workers' promotion as and at when due
6. Provision of health and sanitation facilities

An example of administrative controls being used together withengineering controls and personal protective equipment is: a four-hourlimit for work in a fully enclosed high noise area where earprotectors are required.

It should be noted that administrative controls only reduce the amount of time a worker is exposed to hazard. In essence, they do not eliminate exposure. This thus makes the use of PPE important as discussed in the next section.

3.2.5 Use of Personal Protective Equipment

Personal protective equipment (PPE) is the least effective method ofcontrolling occupational hazards and should be used only whenother methods cannot control hazards sufficiently. PPE can beuncomfortable, may decrease work performance and may createnew health and safety hazards. For example, ear protectors can prevent hearing warning signals, respirators can make it harder tobreathe, earplugs may cause infection and leaky gloves can trapand spread hazardous chemicals against the skin.
Personal protective equipment includes:

1. Eye Protection Using Google

Eye protection embraces spectacles, goggles and handled screens. No eye protection is effective if it is not worn. Common complaintsfrom users are:

- discomfort
- restricted vision
- impaired vision (caused by misting or scratching)

2. Face shield and gloves

Gloves are perhaps the most common personal protectiveequipment, being an almost automatic reaction to the idea of ahazardous agent in contact with the hands. Selection should takeinto account a wide range of parameters. Some of these parameters include:

- The dexterity or skill required to perform the work
- Physical protection against cuts, grazes and bruises
- Whether the wrist and arm need protection as well.
- Permeability of gloves to chemicals
- Dust retention characteristics

3. Protective clothing

At its simplest term protective clothing means overalls or labcoatsfor general-purpose use. They are intended to protect the user (orthe user’s own clothing) from everyday wear, tear or dirt. There are a number of special hazards that may be encountered against whichsuch basic clothing may not be adequate:

- Corrosive liquids which could soak into the clothing and so come incontact with the skin, causing serious damages. Impermeability is thus an important factor here.
- Dust retention: When working with powders, a fabric that holds dustcould generate an airborne exposure hazard as the person movesaround.
- Thermal environment: normal clothing may be too warm or too coldfor a particular environment. In extremes cases, chemical protectiveclothing might be necessary. Typically, this comprises a one-piecesuit made from an impervious material.

4. Respiratory protective Equipment (RPE)

In selecting RPE one should consider:

- The physical nature of contaminant- whether it is gaseous orparticulate
- The chemical nature of the contaminant – whether it is reactive orcorrosive

- Comfort factors

5. ***Hearing Protection***

Hearing protection is perhaps a more descriptive term than thecommonly used ear defenders since it is the hearing that is at risk,not the ears. Protection can take two forms.

- Ear muffs which are fit over and around the ears with a fluid of foam filled cushion sealing them against the head.
- Ear plugs which snugly inside the ear. There are a variety of types,including foam and soft rubber plugs.

As the noise is produced over a range of frequencies the choice ofhearing protection must be based on the measured spectrum of the noise. Choosing hearing protection is only partly amatter of finding protectors with the right attenuation. It is equallyimportant to find ones that are comfortable and practicabl for theWork demand.

3.2.6 Other Administrative Strategies Including Hygiene and Environmental Sanitation

Provision of health and sanitation facilities

Workers health, physical and psychological developments areassociated with the working and the external environment.The general sanitation of the industry and the healthful conditionsare necessary for conserving health or to ensure the protection ofoccupational health safety and hygiene and measuring or providingthe efficiency of the work place.Therefore, an industrial plant should satisfy the following conditionsand facilities:

- The provision of safe potable and adequate water supply.
- Proper collection and disposal of liquid waste.
- The provision of adequate sanitary facilities and other personalservices.
- General cleanness and maintenance of industrial establishment of protecting good maintenance (house-keeping) of the plant.
- Maintaining good ventilation and proper lighting systems.

Water Supply

The provision of safe and adequate water supply is the mostimportant element in industrial settings.Water can be used for the following purposes in an industrial plant:

1. It may be used as raw material in the production process.
2. Used for cooling purposes in the machines

3. Used for cleaning and washing of equipment
4. Used by employees to keep their personal hygiene
5. Serve as a means for waste disposal in water carrying systems
6. For drinking and cooling purposes

In general, the water supply should be safe, adequate andwholesome and which satisfy public health standards. The numberof taps or fountains required varies from 1 for 50 men to 1 for 200men, depending upon the plant arrangement. However, the standardis an average of 1 tap or fountain for 75 persons.

Sanitary Facilities

Observation of many plants or industries in developing countries will indicate that latrines and toilets used by the workers are of aprimitive and unsanitary nature or in some cases there are none at all. In some countries the public health services and labour legislation laydown regulations concerning sanitary facilities to be providedincluding the number for male and female workers.

Example:

- At least 1 suitable latrine for every 25 females
- At least 1 suitable latrine for every 25 males

In a factory where the number of males employed exceeds 500, it issufficient to provide 1 toilet or latrine for every 60 males providedthat sufficient urinals are provided.

Washing Facilities: adequate, suitable and conveniently accessiblewashing facilities should be provided for employees. There shouldbe a supply of running water; in addition, soap and clean towelsshould be supplied and common towels should be discouraged asmuch as possible.
The recommended standards: -

- 1 wash basin for every 15 workers for clean work
- 1 wash basin for every 10 workers doing dirty work
- 1 wash basin for every 5 workers handling poisonous substances or engaged in handling food stuffs.

The walls of washing rooms should preferably be glazed tiles andthe floor made of the same tiles or hard asphalt.

Points to be considered in providing shower services as documented in Takele and Menegsha(2006) include:

- All showers should be separated for male and female workers toguarantee privacy
- Emergency facilities must be available where there is a dangerof skin contamination by dangerous or poisonous substances
- Emergency shower or eye wash facility
- Accessory materials.

Refuse Disposal

Proper solid waste management starting from the source togeneration to the final disposal site is highly required in industrieswhere different kinds of wastes are generated.Industrial solid wastes may contain hazardous materials thatrequired special precaution and procedures. But combustible solidwastes except poisonous and flammable or explosive materials canbe handled in the convenient manner.

Liquid waste collection and disposal

Industrial liquid wastes if not properly disposed could pollute rivers,lakes, environment and drinking water supply.Toxic liquid wastes should be diluted, neutralized and filtered, settled or otherwise chemically treated before being discharged into astream or river or on open land. Under no circumstances should betoxic, corrosive, flammable or volatile materials be discharged into apublic drainage system.

Illumination/lighting

The intensity of light source is measured by the standard candle.This is the light given by a candle, which has been agreed upon sothat it is approximately uniform.The intensity of illumination is measured by the foot-candle. This isthe illumination given by a source of one candle to an area one footaway from the source.

For checking illumination, the foot-candle meter is very useful.Inspectors in determining and measuring illumination at the factoryworkers bench can use it.

The window glass area of the workroom should be (usually) 15-20 %of the floor area.

Advantage of good lighting

- Safeguards eye sight
- Reduce accident and hazards
- Saves the workers time and cut down the amount of spoiledwork and therefore it is economically profitable.

3.2.7 Industrial Health Education

Industrial Health Education according to Ogundele (2017) is aimed at empowering industrial workers with the requisite knowledge, attitude and skills required to adopt safety practices at the work setting with a view to promoting their health and well-being. Industrial Health Education is therefore an important strategy to improve, promote and maintain health of workers. Ogundele (2017) identified three components of industrial Health Education:

1. Industrial health services
2. Industrial health instruction
3. Healthful industrial environment

Industrial Health Services
These are services rendered by the employers or in collaboration with the employees to ensure optimum workers' health and productive. These services are both preventive and curative in nature and are aimed at preventing occupational diseases as well as treating these diseases, if and when they occur.

Proposing an encompassing view of the concept Udoh (1981) as coted in Ogundele (2017) noted that industrial heath services are the procedures carried out by physicians, nurses, dentists, health educators, social workers to:

a. appraise, protect and prmote the health of the employers and employees;
b. counsel employers for the purpose of helping them obtain needed treatment or for arranging work schedule in line with workers' abilities;
c. help in the prevention and control of communicable diseases
d. provide emergency care for injury and sudden illness;
e. promote optimum sanitary conditions and provide adequate and proper sanitary and safe facilities; and
f. protect and promote the health of industrial workers.

Services included in the industrial health component of the industrial health services include:

1. pre-employment medical examination
2. periodic medical examination
3. keeping and maintaining of health record and history

Industrial Health Instruction

This is an organized programme of instruction designed to serve as a tool to inculcate accurate and scientific functional knowledge to aid attitude formation required to adopt safe and healthy behaviour at the work setting. The main essence of this component is prevention of occupational diseases and hazards. It is the first step to the control of industrial diseases and hazards as it has primary prevention as its focus. Ogundele (2017) noted that media for health instruction in the industry include:

1. lectures
2. group discussions
3. film shows
4. Information, Education and Communication materials like health posters, hand bills, flyers, etc.

Healthful Industrial Environment

Work is done in the industrial environment and industrial health is largely dependent on the health of the industrial environment. Healthful industrial environment has been erroneously viewed in the light of physical environment only. Meanwhile, the psycho-social environment also constitutes important aspect of the industrial environment. Indices of a healthful undustrial environment as documented in Ogundele (2017) include:

1. comfortable surrounding with appropriate hearing, lighting, space, ventilation, sanitation and water control
2. control of noise level
3. provision of facilities to rest, obtain and eat healthy food and perform waste disposal functions.
4. Suitabke accommodation for workers and their families
5. Job security
6. Proper training of workers to match work demands
7. Safety regulations to protect workers' health
8. Sanitation in the work place
9. Provision of accident/life insurance scheme
10. Prompt payment of salary.

4.0 CONCLUSION

Every work setting can be potentially harmful to workers because of the presence of hazards. It is therefore important to make efforts to prevent and control these hazards. Prevention as used in this course material refers to primary prevention which deals with strategies and efforts aimed at reducing the possibility of the occurrence of an occupational disorder to zero level. On the other hand, control combines elements of primary prevention with secondary prevention and in extreme case, tertiary prevention. Secondary prevention attempts to curtail the spread or transmission of a health problem that have begun. It can also involve strategies aimed at reducing impact and reducing cost of the health problem. In order to ensure that the work environment is safe and secure, prevention and control strategies must be ensured using various means.

5.0 SUMMARY

Fundamental things to note from this module include:

- Occupational settings are full of hazards thereby predisposing workers to health disorders, injuries and diseases
- Prevention strategies aimed at reducing the possibility of the occurrence of these diseases, disorders and injuries must be put in place by all stakeholders
- Control strategies aimed at reducing the possibility of occurrence as well as impact of health problems must also be ensured.
- Hierarchical steps to preventing and controlling occupational health problems include: elimination, substitution, engineering controls, administrative controls, use of personal protective devices and industrial health education.

6.0 TUTOR-MARKED ASSIGNMENT

1. Differentiate between prevention and control of occupational diseases and injuries
2. State five strategies that could be employed in preventing and controlling occupational diseases

Solution

Difference between Prevention and Control of Occupational Health Problems

1. Prevention refers to actions, efforts and strategies aimed at reducing the possibility of the occurrence of occupational disease or disorder to a zero level. On the other hand, control refers to efforts and strategies aimed at reducing the possibility of spread of an occupational health problem that has occurred. It also refers to efforts and strategies aimed at reducing the impact or effect of the occupational health problem or disease.

2. ***Strategies of Preventing and Controlling Occupational Health Problems***
    1. Elimination
    2. Substitution
    3. Engineering control
    4. Industrial health education
    5. Administrative control
    6. Use of personal protection devices

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