COMPUTERIZATION OF DIAGNOSTIC X – RAY DOSE

(A CASE STUDY OF GBOKO GENERAL HOSPITAL)

BY

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CERTIFICATION

This is to certify that Ugoh, Oliver Tivzua of the Department of Mathematics and Computer Science, Federal University of Technology, Minna, has conducted this project.

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DEDICATION

This piece of work is wholly dedicated to God Almighty and to my dear uncle,Engr. Philip Fasaa Ugoh.

Finally, I must never forget my dear friend, Mr. Iyogun Akhilome for his assistance. He is a friend in need and a friend indeed.

I give glory and honour to God Almighty for making my dream a reality.

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ABSTRACT

Although significant medical benefits are derived from radiographic examinations, diagnostic radiology accounts for the largest contributions to the irradiation in people in most countries of the world. In keeping the radiation dose to a minimum, therefore, requires a research work to study the applications of diagnostic X – rays in hospitals – Nigeria. Consequently, Gboko General Hospital was chosen as a case study and a sample group of 20 patients were cross-examined to determine the levels of X – radiations exposure. In this project, a system has been designed to calculate the X – ray dose. With this system, the radiographer will know the X-ray dose each patient will receive prior to diagnostic examination. This is achieved by inputting the radiographical parameters: $kv_{p,}$ $_{\mathbf{mAS,T,FFD}}$ and patient's thickness into Edmond's formula;

skin dose (mGY) =((836*$(kv_p)^{\wedge 1.74}$ *mAS/$(SSD)^{\wedge 2}$)*(1/T+0.114))/1000

The benefits of the new system are the speed and accuracy of calculating the skin dose.

subject they hate most during their secondary school days, the response from them is "Mathematics". This negative attitude has created a big problem in the computation of X – ray dose using Edmond's formula.

That is: $$\text{Skin dose } (\mu GY) = \frac{836\,(KVp)^{1.74}\,(mAS)\,(1/T + 0.114)}{(SSD)^2}$$

Where

μGY = microGray (unit of skin dose)

KVp = Peak kilovoltage

mAS = microampseconds

SSD = source to skin distance

T = total filtration

There are a lot of problems, with the present system (i.e. the manual system) of processing and storing information. Notable among these problems include:

i. Lack of instruments or devices (like rapmeter) that will measure the exact amount of x – ray dose received by patients; which means that patients are likely to be over – exposed to x – radiations.

ii. Problems of storage – most of the patients' past records had been eaten up by household parasitic insects and rats, due to improper ways of keeping them.

iii. Difficulty in retrieving past records whenever the need arise.

b) To increase accuracy of keeping facts and records as manual system is prone to human stress.

1.4 SCOPES AND LIMITATION OF STUDY

The study on computerisation of diagnostic X-ray dose is a very broad one and sometimes entails an overwhelming cost when much detailed analysis and information are required. Consequently, it is necessary to define the boundaries for this research.

This study is focused on the diagnostic data from General Hospital Gboko as a case study.

Nevertheless, these data has been used to design a structure, which is applicable and adaptable to all Nigerian Hospitals since they generate the same type of data.

1.5 DEFINITION OF TERMS

i. Collimation – The use of heavy metal absorbent to define the dimensions and directions of radiation beam.
ii. Diagnose – Is to identify the nature of a problem, especially an illness.
iii. Diagnostic – The study of diagnosing (diagnose) disease.
iv. GY (Gray) – Is the SI unit of absorbed dose.

$$1Gy = 1Jkg^{-1}$$

v. Ionisation – The removal of an electron from an atomic orbit.

vi. Lead glass – Is a glass with a high lead content for protecting purposes.

vii. Leakage radiation – Radiation that escape from the protective housing of a source.

viii. R (Roentgen) – Is the special unit of exposure

$$1R = 2.58 \times 10^{-4} Ckg^{-1}$$

ix. Rad – Is an old unit of absorbed dose.

$$1Rad = 10^{-2} Jkg^{-1} = 10mGY$$

x. Radiographer – A person who takes x-ray photographs in a hospital.

xi. Radiology – Is the scientific study of x-rays and other radiations (especially as used in medicine).

xii. rem – Is a temporary unit used for dose equivalent.

$$1rem = 10^{-2} Jkg^{-1} = 10mSv$$

xiii. X – ray – A type of radiation that can penetrate solid objects and make it possible to see into or through them.

xiv. Sv (sievert) – Is the SI unit for dose equivalent

$$1Sv = 1Jkg^{-1}$$

CHAPTER TWO

2.0 LITERATURE REVIEW

Despite the fact that ionising radiations contribute greatly to the irradiation of people, its importance cannot be over emphasised.

This chapter discusses:

- Types and sources of ionising radiation
- Effects of radiation
- Brief history of x-rays
- Doses exposed/absorbed
- Radiation protection
- Recommended (acceptable) dose.
- Protection against numerous hazards, and
- The effects of computer on data processing.

2.1 TYPES OF IONISING RADIATION

The principal types of ionising radiations are x-rays and gamma rays (γ-rays) both of which are electromagnetic radiation; and alpha particles, beta particles, neutrons and cosmic rays, which are particle radiation.

2.1.1 SOURCES OF RADIATION

Radiation is not perceived by our five senses – we cannot see, hear, taste, smell or feel it. In the absence of signs to the contrary, we might think that we live in a radiation-free environment; this is certainly not the case. We are continuously bombarded by naturally occurring radiation and to a lesser extent, man-made radiation.

2.1.1.1 NATURAL (BACKGROUND) RADIATION

The largest source of natural radiation results from cosmic rays from the outer space. The atmosphere acts as a shield to absorb this radiation as well as hazardous components of the ultra-violet spectrum. However, at high elevations, this protection is lost and cities such as Mexico city and Denver having approximately 2300m and 1600m above the sea level have a higher than average level of radiation due to this effect.

Another source is from natural radioactivity in our bodies, mainly potassium 40. A sizable amount of this radiation comes from the soil and the building materials. Yet another source of natural radiation is the air we breathe; the air contains radon gas – as we breathe, some of these radioactive dust particles stick to the lining of the lungs, and thus the lungs receive more radiation than the rest of the body.

The other source worth mentioning is the tobacco leaves – the smoke that enters the lungs of smokers may give them up to five times the radiation non-smokers receive.

2.1.1.2 MAN-MADE RADIATION SOURCES

Man-made sources of radiation are quite abundant today, especially in the field of medicine. The most important man-made radiations are x-rays and radioisotopes used for medical diagnosis and treatment. Other sources include: luminous dial wrist watch, fallout from nuclear weapons testing, and radioisotopes emitted from installations where radioactive materials are used, e.g the accidental bomb blast in Lagos state on January 27, 2002. There is the high possibility of increase in radioactive level in that region.

2.1.2 EFFECTS OF IONISING RADIATION

It is obvious that due to the rapid increase in the applications of radiations in most aspect of our lives, both useful and non-useful (biological and material damages) effects of radiation were derived.

Biological effects were first noted in 1896 by some of the early x-ray workers. They noticed that the hair fell off areas that had been exposed to x-rays;

the skin became red, and that skin cancer often developed after a number of years on the areas that had been exposed.

The biological effects of ionising radiation are of two types, somatic and genetic effects. ***Somatic effects*** – This affects an individual directly (loss of hair, reddening of the skin e.t.c). These effects depend on the amount of radiation the part of the body is irradiated and the age of the patient. In general, the younger the person the more hazardous the radiation.

Genetic effect – This affects an individual indirectly. The most dangerous period to receive radiation is before birth. At certain period in development of the foetus, radiation can produce deformities or even death. For instance, during the pre-implantation state (rapid division of fertilised eggs within nine days of conception) radiation can result in the death of the embryo.

Therefore, to avoid the serious consequences of irradiating a developing embryo or foetus, many hospitals and medical centres enforce what is called "10 – day rule". This limits x-rays of the pelvic area in women of productive age for ten days following the onset of a menstrual period, when the chance of conception having occurred is minimal. Despite such precautions, there are times in which due to accident or emergency a developing embryo may be exposed to radiation.

Most experts agree that a dose of 100 mGY or more during the first six weeks after conception is justification for a therapeutic abortion because of the increased chance of an abnormal child. Indeed, genetic effects consists of mutations in the reproductive cells that affect later generations; but in the light of present knowledge, genetic mutations are not considered by most scientists to be a serious problem at the current levels of radiation exposure to the public.

Perhaps the most feared somatic effect of radiation is carcinogenesis, the induction of cancer. Exposure to penetrating ionising radiation have a characteristic pattern of injury, that is, if huge doses are delivered, death can occur in hours, days or weeks. A good example is the human experience that Japanese exposed at Hiroshima and Nagasaki (1945). The survivors of that atomic bomb explosion studied by the United States Atomic Bomb Casualty Commission (ABCC) showed that out of 11900 survivors, 117 persons had leukaemia (blood cancer).

Although radiation can produce biological and material damages if not used properly, it nevertheless has many useful effects.

- In Physics, Chemistry and Engineering research, radiation has been widely used. The study of crystal structures by x-rays (crystallography) is now a powerful method of scientific research.
- In Agriculture, radiation from radioactive chemicals has been used to investigate the growth of certain agricultural products. It is also used to

control insect pests and treating certain foods in order to retard spoilage and increase their shelf life.

- Among all the uses of radiation, medicine is the most important area beneficial to man. Radiographs are used for variety of purposes. In radiology, suspected bone fracture can be investigated since x-rays of certain hardness can penetrate flesh but not bone. When an organ is being x-rayed whose absorptive power is similar to that of the surrounding tissues, a "contrast" medium is given to the patient, orally or by injection, this is less easily penetrated by the x-rays and enables a shadow of the organ to be obtained on a radiograph.

2.2 BRIEF HISTORY OF X-RAYS

X-rays are a form of electromagnetic radiation. X-rays so named because their nature was at first unknown. Professor Wilhem Roentgen in Wurzburg, Germany discovered them in 1895. Roentgen was experimenting with a primitive vacuum tube, then known as Lenard tube. The tube was completely enclosed in an opaque black cardboard box when he happened to notice that a fluorescent screen lying on the bench nearby and consisting of a piece of paper coated with the chemical substance, barium platinocyanide emitted light when and only when the tube inside the cardboard box was being supplied with the high voltage electric current.

2.2.1 PRODUCTION OF X-RAYS

X-rays for diagnostic use are produced when a stream of high-energy electrons (accelerated through a potential difference of 20kv – 120kv) are slowed down or strike a target or bombarding matter. The electrons are produced from a tungsten filament by thermionic emission. They are accelerated in the tube by the electric field force between the electrodes, and then strike the tungsten target. The x-rays are emitted in all directions from the target; only a collimated beam is allowed to escape from the tube head and is directed through the part of the body to be radiographed to strike a film. The intensity of the x-ray beam varies directly with the emitted electrons, which in turn is controlled by the filament current. In modern x-ray tubes, the number of electrons accelerated towards the anode depends on the temperature of the filament, and the maximum energy of the x-ray. Photon produced was determined by the accelerating voltage (peak kilovolt, KVp).

The KVp used for an x-ray study depends on the thickness of the patient and the type of study being done. For instance, x-ray studies of the breast (mamograph) are usually done at 25 – 50KVp, while some hospitals – like Gboko General Hospital – use up to 80KVp for chest x-rays.

The intensity of the x-ray beam produced when the electrons strike the anode is strongly dependent on the anode material. That is, the higher the effective atomic number of the target, the more efficiently x-rays are produced. The target material used should also have a high melting point since the heat produced when the electrons are stopped in the surface of the target is substantial.

Consequently, tungsten with a melting point of 3400 °C and effective atomic number of 74 is used as target in most x-ray machines.

2.2.2 PROPERTIES OF X-RAYS

X-rays possess the following properties such as:

i. They are not deflected by electric and magnetic fields.
ii. They travel in a straight line.
iii. They readily penetrate matter.
iv. They ionise a gas permitting it to conduct electricity.
v. They eject electrons from matter by the photoelectric effect.

In radiography, x-rays produced for diagnostic use have a spectrum of energies with maximum energy equal to the maximum KV generated.

The maximum energy, E of emitted x-rays from an x-ray tube is given by:

$$E = hf = \frac{1}{2} mv^2$$

Where h is the Planck's constant, f the frequency of radiation and m is the mass of electron. V is the velocity of the electron while E is the energy of the x-rays (Nelkon & Parker).

2.2.3 USES OF X-RAYS

Due to many varied properties of x-rays, they have been applied to a wide range of medicine, industrial and scientific problems. X-ray machines are one of the essential tools at the services of Doctors and Dentists.

One of the earliest applications of x-rays was to medicine; being used in both diagnosis and therapy.

- ✓ In diagnosis, x-rays were used to detect abnormalities such as bone fracture, dental cavities and disease conditions such as cancer.
- ✓ Whereas, in therapeutic treatment, x-rays are used to stop the spread of malignant tumours. The age of the bone can also be determined by taking the radiograph of it and compare the development of the bone with a set of standard films.
- ✓ In industries, x-ray radiographs are used to detect flaws non-destructively in castings that are inaccessible to direct observation and to measure the thickness of materials. Casting and welded joints can be inspected for internal imperfection using x-rays.

- ✓ Another form of diagnosis similar to radiograph is fluoroscopy. While radiograph is a static method of diagnosis (that is in form of photographs), fluoroscopy is a dynamic diagnostic method; the process involves screening of patients by passing radiation through them. The transmitted radiation is converted into various signals, which are viewed on the screen. It provides a dynamic picture of the internal organs and is used to screen large population in a short time.

2.3 DOSIMETRIC PARAMETERS

Many of the laws of science such as Newton's first and third laws of motion, the laws of thermodynamics and all the conservation laws are special and more precise statements of the everyday phrase, "you do not get something for nothing". The same applies to the effect produced by ionising radiations and it has therefore always been obvious that these effects can only be brought about if the radiation transfers some of its energy to the materials in which the effect is produced. It should come as no surprise that the so-called ionising radiations have very frequently been measured by the ionising they produced.

2.3.1 EXPOSURE

International Commission on Radiological Units (ICRU, 1980) defined exposure dose of x-radiation at a certain place as a measure of the radiation that is based upon its ability to produce ionisation. The SI unit of exposure is Coulomb Per Kilogram (CKg^{-1}) but Roentgen, R has been used temporarily.

$1R = 2.58 \times 10^{-4} CKg^{-1}$

2.3.1.1 EXPOSURE MEASUREMENT

A free-air chamber is normally used for the measurement of x-rays generated at 300 KV. This device is not useful due to its bulky nature and needs a substantial high voltage supply. Most importantly, it accepts only radiation from a very small solid angle.

For convenience in day-to-day measurements in the field, and particularly when multi-directional radiation is concerned, it is necessary to use a different device-hence cavity ionisation chamber. Ionisation chamber is calibrated against a free-air chamber by placing the free-air chamber in an x-ray beam and measuring the exposure.

2.3.2 ABSORBED DOSE

Absorbed dose, D, is the mean energy imparted by ionising radiation to material of mass dm.

The original special unit of absorbed dose, the rad, is still in used unchanged after a quarter of a century. It was originally expressed in terms of ergs, but with the growing use of SI units was expressed in terms of those units as $10^{-2}JKg^{-1}$. The rad was at first reserved for use only with the quantity absorbed dose, but the ICRU (1971) later extended its use to other radiation quantities having the same dimensions, namely specific energy (imparted), Kerma and absorbed dose index. With the increased use of the SI system of units, the International Commission on Radiological units, ICRU (1975) thought that a special name would be a particular value to radiation users – Gray (GY) is now the recommended unit for absorbed dose. Calorimeter is a device used in measuring absorbed dose.

In principle, absorbed dose can be measured directly by observing the heating effect produced by ionising radiation in the material of interest.

In practice, however, there are many problems. For instance Stahel (1929) made an attempt to measure the energy absorbed per unit volume of water exposed to high-energy photons by the combined use of a calorimeter and a liquid filled ionisation chamber, but the results were rather inaccurate.

The fundamental problems with calorimetric methods of dosimetry are the lack of sensitivity and the difficulty of ensuring low heat exchange between the thermal element and its surrounding in what are often constrained experimental conditions. Under special circumstances, these problems can disappear.

2.4 ELEMENTS OF RADIATION PROTECTION

Early users of radiation, including medical users, were largely unaware of the biological effects of radiation. Consequently, many of these persons worked under conditions that contributed large radiation doses to themselves, and their patients in case of medical users.

We can never completely escape exposure to ionising radiation because there is no method of avoiding the so-called background radiation.

However, to reduce the effects of radiation, studies were initiated by various professional organisations (like the American Roentgen Ray Society and the American Radium Society) to determine acceptable levels of radiation exposure for radiation users. This led to the establishment of the International Commission on Radiological Protection (ICRP) in 1928.

International Atomic Energy Agency (IAEA) also played an important role in setting standard to control the radiation exposure of workers, medical patients and the public. The IAEA together with the World Health Organisation, International Labour Organisation, Food and Agricultural Organisations and Pan American Health Organisation – recently revised and updated its International Basic Safety Standard (BSS) for protection against ionising radiation and the safety of radiation sources. These safety standards will go a long way reducing the hazard of exposure to radiation workers and most importantly enhancing their morals.

This could also have positive psychological implications; patients will have the confidence that they will not be over-exposed to radiation.

Some of the ways of protecting against ionising radiation include:

2.4.1 PERSONAL MONITORING

In order to reduce hazards, the need for measurements therefore arises. Ionising radiation is fairly energetic and produces a number of physical and chemical effects. Some of these effects include: darkening of film, production of light (scintillation) storage of energy in a crystal, (which can later be released as light – thermoluminescence) e.t.c. These are currently being used to measure radiation.

In radiation protection, there are common instruments, which are used to detect radiation. These instruments are often called radiation monitors; those worn by radiation workers are called personnel monitors. Large monitors that can easily be carried about are known as portable monitors, and laboratory or area monitors if they cannot be carried about.

Persons exposed, on the job, to ionising radiation should wear a device to monitor the whole body radiation dose accumulated from day to day. The common personnel monitors are:

2.4.1.1 IONISATION CHAMBER

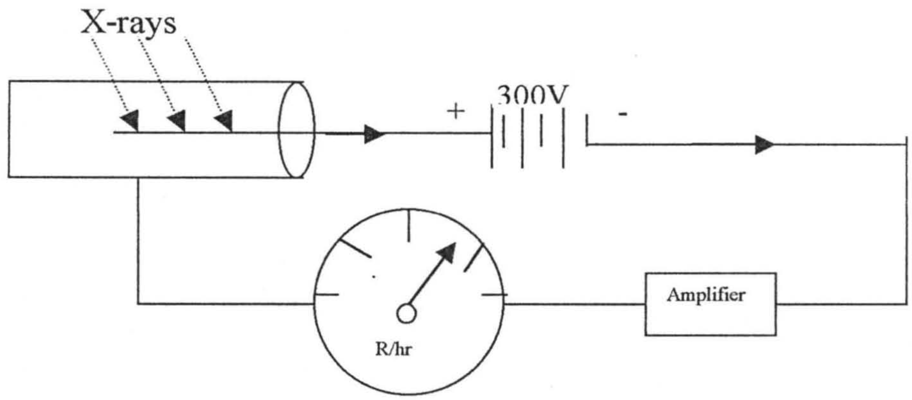


Fig. 2.1: A portable ionisation chamber

In a portable ionisation chamber, the ionisation charges produced in the air-filled chamber are collected, with the electrons going to the positive centre electrode. This weak current is amplified and displayed on a meter. The ionisation chamber has a good response for x-rays, gamma rays and beta rays; but it is relatively insensitive and cannot detect background radiation. It is used to look for relatively high radiation levels ranging from 0.01 – 5R/hr (Fig. 2.1).

Another popular version of the ionisation chamber is the pocket ionisation chamber that can be charged up to a few hundred volts.

A pocket ionisation chamber is a pencil-shaped device when exposed to radiation, the charge of the chamber is partially neutralised. The reduction in charge can be used as an estimate of the radiation exposure to the chamber. Pocket ionisation chambers are useful for recording doses over relatively short time periods, and are worn routinely by persons working near radiation sources with potentially high exposure rates.

2.4.1.2 THERMOLUMINESCENT DOSIMETERS

Exposure of certain substances (e.g. LiF and CaF_2) to ionisation radiation causes electrons to become trapped in energy levels above the ground states. When heated, the trapped electrons return to the ground state and visible light is emitted. The amount of light emitted is measured to estimate the dose delivered by the radiation.

2.4.1.3 FILM MONITORS

The final proof that all protection measures are adequate is given from actually monitoring the dose received by staff. The most common method for long-term monitoring of general body dose is the film badge. Film badges are worn by radiation workers. A film badge consists of two or more small x-ray films, and are designed to estimate the accumulated whole body dose; and usually are worn at chest or waist level. The amount of radiation received by the film emulsion is indicated by the optical density of the processed films. That is, the degree of film blackening can be used to estimate the dose accumulated over the time that the badge has been worn.

Consequently, the following methods are used to reduce the patient exposure:

a) Use of shields to protect the gonads and other sensitive areas of the body that are not included in the area of interest.

b) Use of field limiting devices such as cones and collimators to confine the useful beam to only the area of diagnostic interest. These devices also improve the quality of the radiographic image by reducing the scattered radiation.

c) Use of filters in the x-ray beam to remove low energy x-rays from the beam. Most low energy x-rays are absorbed in the patient and contribute little to the diagnostic information. Other methods are:

d) Use of the highest KVp technique consistent with acceptable image quality. When films of acceptable quality can be produced by one of several techniques, patients dose are low. Generally, a patient dose is lowest with the highest KVp technique.

e) Use of fastest films and screens that still preserve the information needed. And;

f) Use of proper radiographic positioning and film processing techniques to avoid retakes.

2.7 DOSE LIMITS TO PATIENTS

It has been shown in 1.0 that the whole world is living in a continuous sea of ionising radiation with variety of hazards; and the need to reduce such hazards. To this regard, the International Commission on Radiological Protection, ICRP (1991) recognises three classes of exposures: the medical exposure, the occupational exposure and the public exposure.

i. Medical exposure is the dose received by individuals undergoing medical treatment.

ii. Occupational exposure is the dose received by radiation workers like radiologist, nurses, radiographers, e.t.c. in the controlled areas.

iii. Public exposure – this is the dose given to the general population excluding Intentional Medical exposures and radiation workers.

The dose given in medical exposure has a direct variation with the age of the patient. That is, dose = 2(N – 18) rems, where N is the age of the patient.

Thus, the dose limit is 2 rems, which is 20Sv. The dose received by radiation workers and the population per year as recommended by ICRP (1991) is shown in table 2.1

2.8 THE EFFECT OF COMPUTER ON DATA PROCESSING

2.8.1 BRIEF INTRODUCTION

A wide spread marvel at the Computer predicts this research. Most often, people discuss about the mystical power of Computer. A lot has been read from the national dailies. The summary of these literatures and discussions is that the COMPUTER MACHINE solves varieties of problems.

There was a common erroneous notion that the computer machine itself solves any problem fed into it. It is this notion that prompted this research.

Tanimoto (1989) stated that a computer comprises hardware, software and human ware. Literally, hardware is the physical component of the computer system. Hardware per se would remain a hunk of metal totally useless except driven in its data processing functions by appropriate programs. These programs are collectively called softwares. Human ware comprises of all the professionals and users of the computer system. The computer system also includes the Disk Operating System (DOS), used for booting the machine and the language translators used for translating written instructions into computer language (machine code) for it to execute.

In essence, the computer system consists of three components:

i. The hardware

ii. The software, and

iii.The human ware

2.8.1.1 THE HARDWARE

Hardware is the integrated, physical electro-mechanical components that lay men generally call the Computer. It operates according to the instructions stored in its memory.

The memory accepts, stores data and performs arithmetic and logic operations on the data with little or no human intervention, and produces output from the processing (Prince, 2001).

The hardware has three essential parts. These are:

a. Input

b. Central processing unit (CPU) and

c. Output

<u>The Input Unit</u> – This is the feature for entering data and instructions into the computer machine for necessary processing and execution so as to produce desired results. The keyboard is the commonest input unit.

<u>The Central Processing Unit (CPU)</u> – This is often referred to as the heart of the computer. This part controls the activities and various operations taking place in the computer. The CPU has three units. These are:

i. The control unit (CU)

ii. The Arithmetic and logic unit (ALU) and

iii. The Primary memory

The control unit directs the sequence of operations, produces a signal that acts as commands for internal circuits, to execute set of instructions and communicate with input device, output device and the memory. The ALU carries out the arithmetic computations and logical operations. The primary memory is that unit that holds (or stores) instructions, data, intermediate and final results. The output unit is that part which serves the purpose of presenting computer result to the user.

2.8.1.2 THE SOFTWARE: - This refers to the collection of programs, which control the activities of a computer. A program is a sequence of instructions or commands, which a computer follows to perform a specific task.

Sell P.S. (1992) classified computer software into two broad categories: system software and application software.

System softwares are special programs that manage the computer resources. They act as an interface between the user's program and the hardware. System software is usually purchased with the computer hardware. Examples of system software are disk operating system (DOS) and UNIX.

2.8.1.3 THE HUMAN WARE: - This refers to the user of the computer hardware and software for executing a given task. In data processing department, the human ware could be the system analyst, programmer or operator.

2.8.2 DATA PROCESSING

The term data refers to un-organised facts collected from various sources. For example, in the system under study, the data to be used are the four radiographical parameters: voltage, current, time and the thickness of the patient. These parameters alone cannot be used to make a meaningful decision about the patient skin dose; they must be collected together and manipulated in one fashion or another, so as to produce useful information about the patient's dose. Therefore, all the activities carried out on these raw parameters are referred to as data processing.

Thus, data processing is the technique of collecting and manipulating data in an organisation, for the purpose of producing useful information for the top-level management to take useful decisions.

2.8.3 THE USE OF COMPUTER IN DATA PROCESSING

Manual data processing is very common in Nigeria and it suffers three major problems:

a) Speed – There is delay in processing and generating of information (i.e. patients absorbed dose).

b) Accuracy – manual processing are prone to errors.

c) Storage – it is very difficult to retrieve manually stored data promptly.

Collin *et. al.* (1980) stated that most computers can be used for many purposes; These are GENERAL PURPOSE MACHINES.

One of the uses of computers is data processing. This is possible because the various units of computer machine can co-ordinate effectively using the suitable software to process raw data and transform it into useful information.

The effectiveness of computer lies in its three features:

- High speed of processing – most often, the time taken by computer to process data is in milliseconds (mS), microseconds (μS) or even nanoseconds (nS).
- Accuracy – The result produced by computer is often error free. That is, it is very accurate provided correct data are fed into it. Computer mistakes are often due to wrong data or wrong instructions being fed into it. (GIGO = garbage in – garbage out).
- It has memory for storing data and this data can easily be retrieved at any time.

These attributes make computer machine a more effective tool of processing data than the manual techniques.

This research is focussed on exploiting computerised data processing advantages to improve the operations efficiency at the x-ray department of Gboko General Hospital in particular, and all hospitals in Nigeria.

CHAPTER THREE

3.0 DATA ANALYSIS

INTRODUCTION

Before going into development of any system, the programmer or system analyst must first of all study the existing system, meet with the domain experts (experts in any given field) to understudy the manual procedures to enable him/her understand how things are done manually and how best he/she can make use of computer to speed up the process and also provide efficiency.

The process of system analysis and design can be carried out in five stages:

i. System Investigation: - This involves identifying information needs of a system and the feasibility of meeting these needs.

ii. System Analysis: - This process involves detailed examinations of the current information flow and the drawing up of specifications of a new system.

iii. System Design: - This involves the process of devising an alternative information system.

iv. System Development and Implementation: - This is the stage where the designed information system is transferred from paper to physical reality. The process includes development, testing and training of the end users of the system.

v. System Maintenance: - This is monitoring and evaluating of the new system, and the adoption of modifications where necessary.

The last three stages however shall be discussed in chapter four.

3.1 SYSTEM INVESTIGATION

System investigation involves the identification of the problems and information needs of a system.

3.1.1.0 EXISTING SYSTEM

Special techniques abound in x-ray diagnosis such as:

i. Neuroradiology – This is the technique used by the specialist (Neuroradiologist) to visualise the tiny capillaries in the search for defects.

ii. Penetrated grid film – radiographs exposed at high penetration are most valuable in the assessment of mediastinal structures. They are also useful in checking lesions behind the heart and abnormalities of the bony thoracic cage; and

iii. Conventional x-ray techniques consisting of posterior – anterior (P/A) and anterior – posterior (A/P) radiographs.

The chest radiograph is P/A when the content of the ribs cage (lungs, kidney and the heart) is viewed, while A/P view is used when you want to view the ribs.

3.1.1.1 THE X-RAY MACHINE SPECIFICATION

The x-ray machine installed at Gboko General Hospital is Roentgen 501 with the maximum rating of 150KVp and 1000mAS. It has an inherent filtration of 0.7mm Aluminium and added filtration of 0.8mm Aluminium, this is very low compare to standard x-ray machines whose filtration constant ranges from 2 – 3 mm Aluminium. The machine is a 3 – phase generator. The x-ray machine has the following technical specifications:

Type of the x-ray machine	___	Roentgen 501
Manufacturer	___	Watson Engineers, England
Year of Manufacture	___	13th April 1983
Phase of the machine	___	Three
Power rating	___	150KVp, 1000mAS
Inherent filtration	___	0.7mm Aluminium
Added filtration	___	0.8mm Aluminium
Total filtration (T)	___	(0.7 + 0.8) 1.5mm Aluminium

3.1.1.2 DETERMINATION OF PATIENT SKIN DOSE

X-ray machine was set up during routing medical examination. The patient was made to stand, sit or lie down on x-ray tracer between the x-ray source and the recording medium (x-ray film) depending on the type of body projection. Emphasis of this project is on the chest x-ray examinations.

In the case of Anterior – posterior (A/P) radiographic view of the chest x-ray, the patient was made to sit or stand facing the x-ray source directed to the area of interest and the x-ray film hang on a fixed stand at the back of the patient. Before the x-ray machine was put to use, the distance from the x-ray source to the film (FFD) was noted; Gboko General Hospital uses FFD of 120 cm.

Furthermore, for the chest x-ray examination, voltage (KVp), current (mA), time (S) were set up on the control panel after switching on the x-ray machine. The x-ray film was exposed after obtaining an approximate thickness of the patient. The distance from the x-ray source to the skin of the patient (SSD), however, was determined from the patient's thickness and FFD (SSD = FFD – thickness).

(See fig. 3.1 below)

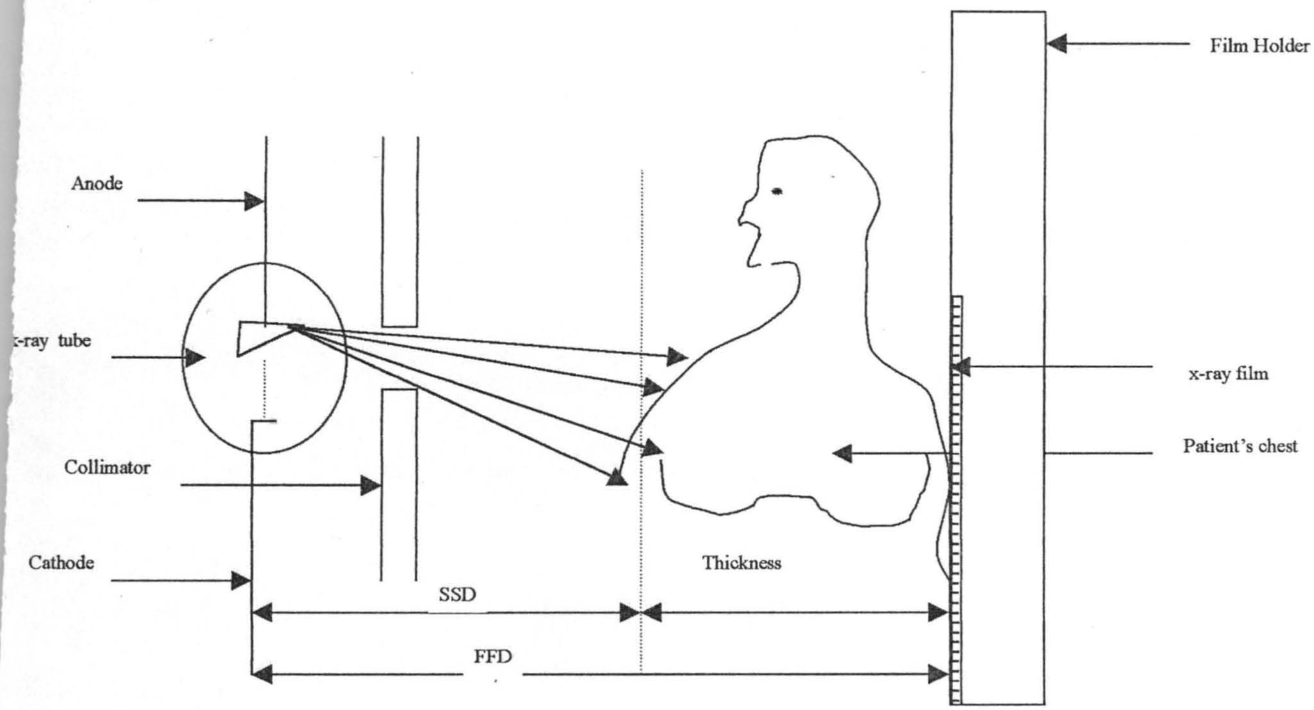


Fig. 3.1: A diagram showing set up of the x-ray machine for A/P radiographic view of the chest.

The skin dose was calculated based on radiographic parameter of KVp, mAS, SSD and T using the Edmonds (1984) formula. It should be noted that this formula and the one in section 1.1 are the same. The only difference is that, while the former calculates skin dose in milliGray (mGY), the latter is in microGray (μGY).

$$\text{Skin dose (mGY)} = \left[\frac{836\,(KVp)^{1.74}\,(mAS)}{(SSD)^2}\,(1/T + 0.114)\right]/1000$$

This relation is appropriate for three-phase generators. It follows that the x-radiation dose derived by single-phase generators is calculated by the same relation above if the constant 836 is replaced by 418.

Using Edmond's formula, the skin dose of each patient was determined. For instance, the following radiographic parameters: KVp = 70, mAS =10 and SSD = 102 were set for an adult male patient, with a chest thickness of 18cm, who came for A/p radiographic view of the chest. Substituting these parameters in the relation equation above, we have:

$$\text{Skin dose (mGY)} = \left[\frac{836\,(KVp)^{1.74}\,(mAS)}{(SSD)^2}\,(1/T + 0.114)\right]/1000$$

$$= \left[\frac{836\,(70)^{1.74}\,(10)}{(102)^2}\,(1/1.5 + 0.114)\right]/1000$$

$$= 1.018455738$$

That gives the skin dose for this particular patient as 1.02mGY.

Similarly, the skin doses for other patients were calculated using the same relation as above.

3.1.1.3 PRODUCTION OF THE RADIOGRAPH (X-RAY PICTURES)

All that is needed to make an x-ray image is an x-ray source and a film wrapped in a black paper called cassette on which to record the image. Markers "L" and "R" are used to denote left and right of the patient's body. The patient was made to stand or sit facing the x-ray source or backing it as the case may be; depending on the type of body projection. After setting all the radiographical parameters – which are on the control panel of the x-ray machine located at some distance from the x-ray tube behind the protective screen – the film was exposed. The exposed film is then processed in the dark room.

Unfortunately, x-rays cannot be focused to make a picture as with a camera. X – ray images are basically images of shadows cast on film by the various structures in the body; they were once called skiagraph, which is Greek for shadowgraphs.

3.1.2 PROBLEMS OF EXISTING SYSTEMS

It is obvious that one can state the following problems without prejudice in any system in which data processing is done manually on paper.

3.1.2.1 CONVENIENCE

As the climate of thought is changing from a static data processing (paper work) to a dynamic one (electronic data processing), going through pages of books for vital information becomes boring, tedious and rather uninteresting as compared to clicking and typing the required information on the computer and the computer searches for it and gives you the information in a blink of eyes.

3.1.2.2 STORAGE

Large volumes of books are needed to keep accurate and comprehensive records of patients in x-ray department.

3.1.2.3 INFORMATION RETRIEVAL

Searching for a piece of information from books is indeed time consuming compared to the use of a computer.

3.1.2.4 OVER EXPOSURE TO IONISATION RADIATION

Patients are likely to receive doses more than that required since the radiographers are less aware of the amount of radiation they are giving to patients.

3.2 SYSTEM ANALYSIS

System analysis is the process of gathering facts, interpreting facts and using the information to recommend improvement to the system.

3.2.1 INFORMATION ACCESSIBILITY

The information regarding this project were obtained from the following:

a) Experts – that is the radiologist (who is in charge of the x-ray department) and the radiographer (one who produces the radiograph).

b) Written document – these include journals, texts and records kept in the x-ray department.

c) Direct involvement of the research; the researcher was involved in taking note of the patient's thickness, as the parameter had no record.

3.2.2 ANALYSIS OF DATA

The next stage of analysing the data is geared towards determining why certain procedures are used and how to improve the performance of the system.

In this regard, tools such as system analyst checklist and program flowchart shall be used.

System Analyst Checklist – This tool consists of questions that give insight to major attributes to be addressed in evaluating a system.

Questions:

1) Are the functions and objectives of the current or existing system well defined?
2) Are the forms, files, procedures and reports well documented?
3) Are the processes, for instance determination of the absorbed x-ray dose, well defined? And are they working well?

Software implementation	15,000.00
Personal computer (Pentium II Processor)	80,000.00
A laser jet printer (11600 DeskJet)	30,000.00
A functional uninterrupted power supply to avoid accidental	
Loss of data	25,000.00
A keyboard and mouse	8,000. 00
Training (3 weeks)	5,000.00
Installation	10,000.00
About three packet of diskette for constant backup	1,500.00
Miscellaneous	5,500.00
Total	₦ 25,000.00

B. **COSTS OF OPERATION**	₦ : K
Suppliers for one year	50,000.00
Equipment maintenance	10,000.00
Program maintenance	10,000.00
Utilities	15,000.00
Labour cost	12,000.00
2 A/C (21/2HP)	50,000.00
Miscellaneous expenses	15,000.00

Total	₦ 162,000.00
Grand Total (A and B)	₦387,000.00

Benefits of the new system:

i. Exact absorbed dose is known prior to examination

ii. The system shall give a feed back when the skin dose exceeds 1.5mGY

iii. Allows quick availability of records.

iv. Reduce cost of stationeries

v. Security of records

vi. Better planning of information

vii. Can be installed in a website for sharing of computer resources.

CHAPTER FOUR

4.0 SOFTWARE PROGRAM DEVELOPMENT

4.1 INTRODUCTION

System software is basically a program; without it, the hardware cannot be put into effective use. To develop an enduring system, certain stages of developments are planned, structured and implemented.

4.2 CHOICE OF SOFTWARE PACKAGES

The choice of programming for a particular project depends on some factors such as the type of data, the volume of data, and the type of manipulation that will be done on the data.

Data for the computerisation of diagnostic x-ray dose involve scientific calculations. Consequently, the following software packages are recommended.

QBASIC - a version of BASIC with which the application software for this project is developed.

Other packages include: Microsoft Visual FoxPro, Pascal and C^{++}.

4.3 FEATURES OF LANGUAGE CHOSEN

BASIC is a versatile and a popular language. Beside its well-known popularity for Microcomputers, a significant number of large microcomputers used for business applications have BASIC as a primary language. Indeed, BASIC is the language of choice for certain applications. Matrix algebra, String manipulations and file-handling operations are all easier to accomplish in BASIC than in FORTRAN, Pascal or COBOL.

4.3.1 The Basics Of BASIC

BASIC is a high level language developed at Darthmonth College, U.S.A, in 1964 by Professor John Kemeny and Thomas Kurtz. The word BASIC is an acronym for Beginners All-Purpose Symbolic Instruction Code. It is an easy to learn language designed for the people who are first timers in computer programming, to solve problems on varieties of applications on many different types of digital computer.

A very good feature of BASIC language is that it is readily available on most microcomputers. Hence developing a BASIC programme is a task that can be achieved in little time, with little effort and little cost.

4.3.2 WHY QBASIC?

There are quite a number of versions in BASIC language. Some of these include:

i. GWBASIC

ii. BASICA

iii. TURBOBASIC

iv. QBASIC

In this project, QBASIC is used due to the following merits:

a) Statement (or line) numbers are optional in QBASIC.

b) Provide menu features that perform the actions of BASIC commands (RUN, LOAD and DELETE) and

c) The logics of software developed using QBASIC are easily understandable by users.

4.4 SPECIFICATIONS

Specification is the first stage involved in any program development. A clear understanding of the nature of the problem is required at this stage. The specification should contain details of what the program is expected to do. At this stage, we also determine the required input data as well as the output information.

4.4.1 INPUT SPECIFICATION

The following input data were required.

a) Name

b) Patient's number

c) Voltage (KVp)

d) Current (mAS)

e) Fixed focal distance (FFD)

f) Patient thickness

g) Age

h) Sex

4.4.2 OUTPUT SPECIFICATION

The output is what is expected to be produced by the new system. The program developed has the following output.

i. Individual absorbed skin dose (Appendix B_1)

ii. List of patient's cross-examined for chest x-ray (Appendix B_2)

4.5 SYSTEM DESIGN

The emphasis of system design is to develop a new system that helps to achieve the goals and objectives of the existing system. That is, the design must address all aspects of the existing system, the modifications in respect to the problems and requirements of the system as elicited by the analyst.

Three major considerations are involved in system design.

i. Hardware considerations

ii. Software considerations

iii. Human-ware considerations

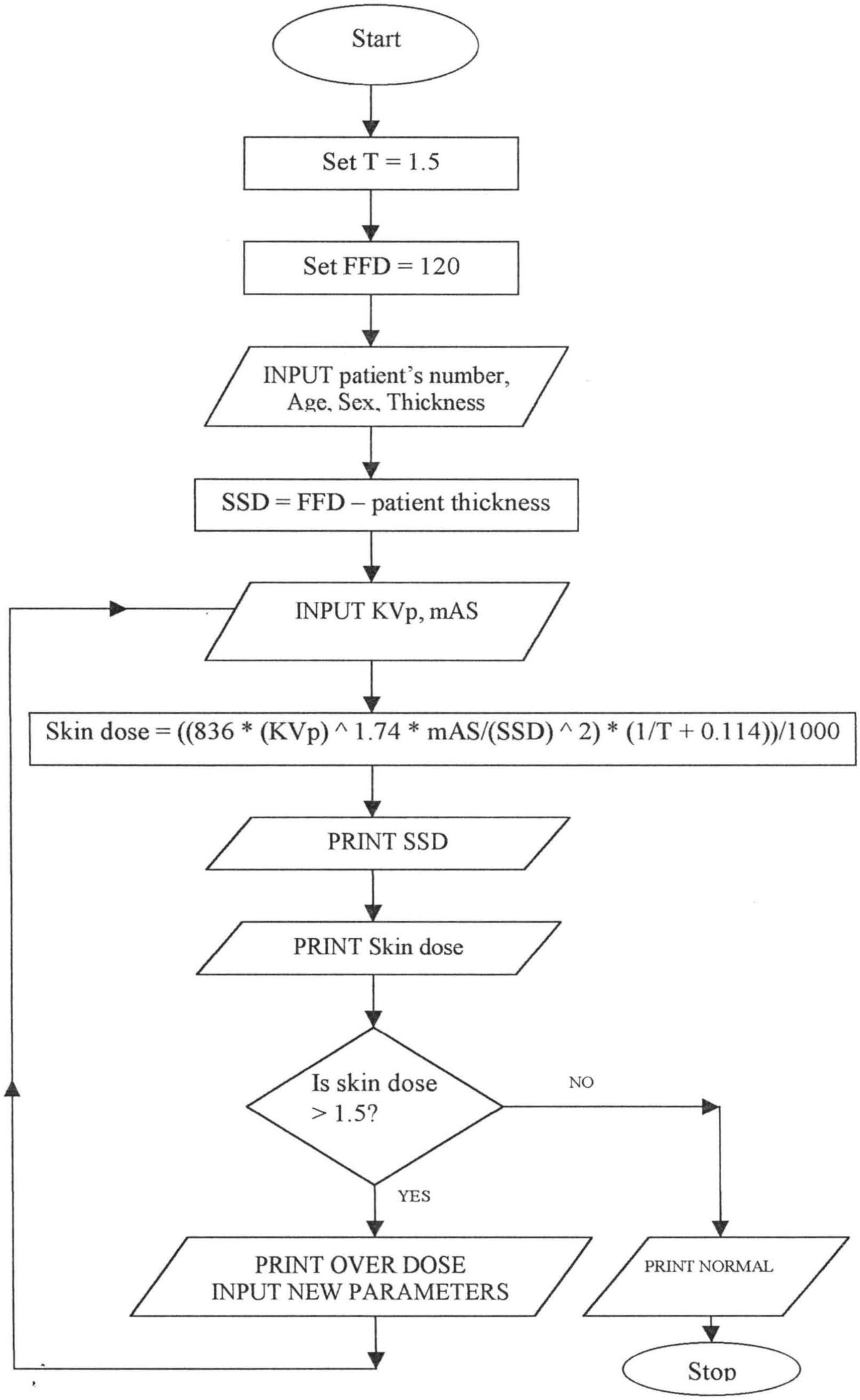
In this project, greater emphasis will be laid on software design and development because it is the bedrock of the new information system.

4.5.1 SOFTWARE DESIGN

The design stage defines an outline of how to solve the problem. This outline is usually in the form of an algorithm; an algorithm is a description of the step-by-step method of solving a problem. There are many ways of implementing algorithm. Some include:

- ❖ Flow charts
- ❖ Pseudo codes
- ❖ N – S diagrams

In this program, flow chart is most applicable.


Start
Set T = 1.5
Set FFD = 120
INPUT patient's number, Age, Sex, Thickness
SSD = FFD – patient thickness
INPUT KVp, mAS
Skin dose = ((836 * (KVp) ^ 1.74 * mAS/(SSD) ^ 2) * (1/T + 0.114))/1000
PRINT SSD
PRINT Skin dose
Is skin dose > 1.5?
NO
YES
PRINT OVER DOSE
INPUT NEW PARAMETERS
PRINT NORMAL
Stop

4.6 WRITTEN PROGRAM

From the algorithm obtained at the design stage, the researcher proceeds to transform the outline into a form understandable by the computer. This involves coding the algorithm in a suitable computer language – QBASIC.

The program code in Appendix A is a documentation of how the system runs.

It should be noted that this program calculates only doses for the radiographic views of the chest x-rays. However, it can be expanded to cover all other radiographic views such as skull, abdomen and leg.

4.7 PROGRAM TESTING

When coding is complete, the program is given a desk check or dry run. This involves inventing simple test data and manually going through the program to ascertain the result before typing into the computer.

The program under view has been successfully compiled, executed (run) and evaluated by comparing the results with those obtained during the desk check; as shown in Appendix B.

There are four types of conversion commonly used: Direct, Pilot, Phased and Parallel conversion.

4.10.1 DIRECT CONVERSION

This is the process of change from the old information system to the new one in one fold expensive move. That is, the old one is kept aside in the event of failure of the new system. The organisation can easily revert to the old system.

4.10.2 PILOT CONVERSION

This conversion process applies the new information system to only a part of the organisation, until it is proven before being applied to other parts of the organisation.

4.10.3 PARALLEL CONVERSION

In this method, both the old system and the new system are run concurrently. Their output are being compared and reasons for difference resolved, until the new system has proved satisfactory.

This system of conversion is less risky but expensive.

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APPENDIX A (PROGRAM CODE)

APPENDIX A1: PROGRAM CODE FOR AN INDIVIDUAL PATIENT UNDERGOING DIAGNOSIS

```
REM PROGRAM TO CALCULATE THE SKIN DOSE OF AN INDIVIDUAL PATIENT WHO IS ABOUT
REM TO UNDERGO A MEDICAL EXAMINATION USING DIAGNOSTIC X-RAYS.

CLS
INPUT "ENTER PATIENT NAME", PatName$
INPUT "ENTER PATIENT NUMBER", PatNo$
INPUT "ENTER PATIENT AGE", Age$
INPUT "ENTER PATIENT SEX", Sex$
INPUT "ENTER mAS", mAS
INPUT "ENTER KVp", KVp
INPUT "ENTER PATIENT'S THICKNESS", PATHICK
INPUT "ENTER FFD", FFD
SSD = FFD - PATHICK
SKINDOSE = ((836 * (KVp) ^ 1.74 * mAS / (SSD) ^ 2) * (1 / 1.5 + .114)) / 1000
PRINT " PAT.NAME  PAT.NUM  AGE   SEX CURRENT VOLTAGE PAT.THICKNESS FFD SSD SKIN
DOSE"
PRINT "                          (mAS)    (KVp)      (cm)       (cm)  (cm)  (mGY)"
PRINT TAB(2); PatName$;
PRINT TAB(12); PatNo$;
PRINT TAB(20); Age$;
PRINT TAB(27); Sex$;
PRINT TAB(33); mAS;
PRINT TAB(39); KVp;
PRINT TAB(50); PATHICK;
PRINT TAB(59); FFD; ;
PRINT TAB(64); SSD;
PRINT TAB(69); SKINDOSE;
IF SKINDOSE > 1.5 THEN
PRINT "OVERDOSE, TRY AGAIN"
END IF
END
```

APPENDIX A2: PROGRAM CODE FOR A GROUP OF PATIENTS UNDERGOING DIAGNOSIS

```
REM THIS PROGRAM COMPUTES THE SKINDOSE OF A GROUP OF PATIENTS USING THE
REM EDMOND'S FORMULA- WHO CAME FOR CHEST X-RAY DIAGNOSIS

 CLS
DATA 1133,ADULT,F,10,70,18,120
DATA 1142,ADULT,F,20,80,19,120
DATA 1118,ADULT,M,15,70,18,120
DATA 1125,ADULT,M,20,65,17,120
DATA 1149,ADULT,M,20,60,16,120
DATA 1157,ADULT,F,20,75,18,120
DATA 1158,ADULT,F,20,60,15,120
DATA 1160,ADULT,M,15,70,18,120
DATA 1172,ADULT,M,30,80,19,120
DATA 1179,ADULT,F,20,70,16,120
DATA 1309,CHILD,F,10,70,14,120
DATA 1326,CHILD,M,20,75,17,120
DATA 1344,CHILD,F,30,80,21,120
DATA 1223,ADULT,F,15,65,17,120
DATA 1236,ADULT,M,20,60,15,120
DATA 1252,ADULT,M,10,70,17,120
DATA 1306,CHILD,F,15,75,18,120
DATA 1139,CHILD,M,10,65,13,120
DATA 1145,ADULT,F,20,80,20,120
DATA 1170,ADULT,M,25,85,23,120

PRINT "PAT.NUM   AGE   SEX CURRENT VOLTAGE PAT.THICKNESS FFD   SSD SKIN DOSE
REMARK"
PRINT "                          (mAS)     (KVp)      (cm)       (cm)  (cm)  (mGY)"

FOR K = 1 TO 20
READ PatNo$, AgE$, Sex$, mAS, KVp, PATHICK, FFD

SSD = FFD - PATHICK
SKINDOSE = ((836 * (KVp) ^ 1.74 * mAS / (SSD) ^ 2) * (1 / 1.5 + .114)) / 1000


PRINT TAB(1); PatNo$;
PRINT TAB(11); AgE$;
PRINT TAB(19); Sex$;
PRINT TAB(23); mAS;
PRINT TAB(31); KVp;
PRINT TAB(41); PATHICK;
PRINT TAB(50); FFD; ;
PRINT TAB(56); SSD;
PRINT TAB(62); SKINDOSE;
IF SKINDOSE > 1.5 THEN
     PRINT TAB(72); "OVERDOSE"
ELSE
     PRINT TAB(72); "NORMAL"
END IF

NEXT K

END
```