EFFECT OF X-RAY EQUIPMENT DOWNTIME ON PATIENTS SATISFACTION IN A TERTIARY INSTITUTION IN BENIN CITY

BY

ABU ABDULMALIK

BMS2005172

DEPARTMENT OF RADIOGRAPHY

SCHOOL OF BASIC MEDICAL SCIENCES

COLLEGE OF MEDICAL SCIENCES

UNIVERSITY OF BENIN CITY

BENIN CITY

OCTOBER 2025

EFFECT OF X-RAY EQUIPMENT DOWNTIME ON PATIENTS SATISFACTION IN A TERTIARY INSTITUTION IN BENIN CITY

BY

ABU ABDULMALIK

BMS2005172

DEPARTMENT OF RADIOGRAPHY,

BASIC MEDICAL SCIENCES,

UNIVERSITY OF BENIN

A PROJECT SUBMITTED TO THE DEPARTMENT OF RADIOGRAPHY IN PARTIAL FULFILLMENT FOR THE REQUIREMENT OF THE AWARD OF BACHELOR DEGREE IN RADIOGRAPHY (B.RAD)

SUPERVISOR

MRS F.O. IGBENEDION

OCTOBER 2025

CERTIFICATION

This is to certify the project on EFFECT OF X-RAY EQUIPMENT DOWNTIME ON PATIENTS SATISFACTION IN A TERTIARY INSTITUTION IN BENIN CITY written by ABU ABDULMALIK with matriculation number BMS2005172 in partial fulfillment of the Bachelor of Radiography Degree (B.Rad) in the DEPARTMENT OF RADIOGRAPHY, SCHOOL OF BASIC MEDICAL SCIENCES, UNIVERSITY OF BENIN.

……………………………

MRS. F. O. IGBINEDION ……………………

(Supervisor) Date

……………………………

MRS. F. O. IGBINEDION ……………………

(Head of Department) Date

___________________________ …………………

EXTERNAL EXAMINER Date

APPROVAL

Project Title: EFFECT OF X-RAY EQUIPMENT DOWNTIME ON PATIENTS SATISFACTION IN A TERTIARY INSTITUTION IN BENIN CITY

Supervisor's Name: Mrs. F. O. Igbinedion Signature and Date ....

Head of Department: Mrs. F. O. Igbinedion Signature and Date ....

DEDICATION

I dedicate this work to God almighty and to my late father Mr.A.T Abu and my loving mother Mrs. Abu, also tp my siblings; Abu Abubakar, Abu Ibrahim, Abu Mariam, Abu Mariam, Abu Aisha, Mr and Mrs. Akidenor and uncle Dozie Okolie.

ACKNOWLEDGEMENT

My profound gratitude firstly goes to Almighty God; the beginning and the end, which is the foundation of my study in this noble university. My sincere gratitude and appreciate goes to my supervisor, MRS IGBINEDION F.O., who was not only a supervisor but the best HOD I had during my stay in this institution. I acknowledge in a very special way the my lecturers Dr Okungbowa G.E, Mrs Okeh E.O and Elder Nwadike U.I for having a positive impact on my academics, May Almighty God to bless you all.

My appreciation also goes to the staff of University of Benin Teaching Hospital, especially chief Becky; for her immense support and guidance throughout my clinical posting days which helped me a lot in writing this seminar. I am grateful. Words cannot express my profound gratitude to my late FATHER, MR ABU and my MOTHER, MRS ABU for their love, care, support, advice and parental blessings. You struggled day and night to see to my welfare in school. You are the best parents I have ever seen. I will ever remain faithful to your advice and love anytime. I also want to appreciate my siblings; Abubakar, Ibrahim, Mariam, Aisha and of course my sister and her husband Mr & Mrs Akidenor and Dozie Okolie you all are the best.

Finally I wish to appreciate "D'QUANTUM CLASS OF '025"

I love and will miss you all by the end of our programme. Thanks and remain bless.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract

X-ray imaging is crucial in diagnosis and treatment planning but the failure of equipment to deliver services efficiently is major challenge to service delivery in most of the developing healthcare systems. This paper evaluated the causes, incidence and outcome of X-ray equipment down times on patient satisfaction at a tertiary hospital in Benin City. This was a descriptive cross-sectional study, in which 200 patients were surveyed by use of a structured questionnaire. Descriptive statistics and Chi-square tests at 0.05 level of significance were used to analyze the data. The results showed that poor maintenance was rated as the significant reason to the downtime, and 74 percent of the participants indicated that the equipment failure was common. Frequently, over half of the patients (56%) had waited because of machine failure, and downtime was found to have a significant negative impact on the flow of patients, the waiting time, and the delay of treatment. The patient effect was high as most patients highlighted discontentment, anxiety, and having to revisit another day because of cancelled appointments. The chi-square findings indicated that there was a statistically significant correlation between equipment downtime and delayed care (kh2 = 92.45, df = 16, $p < 0.0001$), which confirmed the fact that equipment downtime adversely impacts on service quality and patient satisfaction. The researcher makes the conclusion that the direct impact of X-ray equipments downtime on patient care and satisfaction in UBTH is negative. It suggests that preventive maintenance schedules, quick-response technical support and better communication with patients during a service interruption be implemented. Improving equipment management practices will improve continuity of service delivery, decrease patient dissatisfaction, and boost the general efficiency of diagnostic services in tertiary health institutions.

Keywords: X-ray downtime, patient satisfaction, radiology services, maintenance, service delivery, UBTH

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

The medical imaging post cannot possibly be overrated in the ever-evolving healthcare setting. Diagnostic imaging more so through the application of technology such as X-ray, it is worthwhile that appropriate diagnosis and early interventions are made. This machine is usually used as the first step leading to the diagnosis of a huge number of disorders including fractures and fatal illnesses like cancer or internal bleeding. Without timely and accurate imaging results, there is a significant issue in the inability of the physicians and other health personnel to make judgments, which may influence patients. The radiographers are central to the process of this diagnosis; they are the ones who perform the task of operating the equipment and ensuring that images they produce are clear, accurate and reliable (Ehrlich and Daly, 2009).

Nonetheless, despite the fact that radiography is a crucial service in the healthcare system, most health care systems, particularly developing health care systems such as in Nigeria, have had to grapple with equipment functionality and maintenance problems. Among the major issues are the periods of the downtimes of the X-ray equipment when these crucial machines are not in operation, which can usually be caused by technical breakdowns, shortage of spare parts, poor maintenance, or old-fashioned equipment. These interruptions may take the form of several hours to a few days, which have a serious effect on the efficiency and quality of radiological services (CADTH, 2020). In University of Benin Teaching Hospital (UBTH) which is among the leading tertiary hospitals in Nigeria, the impact of downtime is not technical or logistical but very personal and emotional to both healthcare professionals and patients (Ng'andwe & Bwanga, 2022).

The frequency and the time span of equipment downtime may vary. Whereas a few institutions can handle minor repairs within a short time, others have long downtimes because of insufficient maintenance or unavailability of parts (CADTH, 2020). Such disturbances have the ripple effect of affecting not only the radiographers on the ground whose daily operations are directly affected by the machines, but also other health care practitioners who require prompt imaging services. Surgeons, physicians, emergency room doctors use the X-ray images to make life saving decisions. Delays in the clinical decisions when the machines are offline might impact the patient care outcomes (Adem et al., 2023).

Radiographers are burdened with a lot of responsibility in times of downtime since they are the ones who operate the equipment and also make sure that it is running smoothly. Emotional and mental pressures on top of an already straining job are usually caused by frustration of having to deal with malfunctioning equipment. This interferes with their working process, and causes them a growing patient backlog. They are also required to deal with the stress and anxiety of patients that have been left waiting long waiting on vital imaging results in most cases (Ng'andwe & Bwanga, 2022). Radiographers also often find themselves in an awkward situation when they cannot effectively carry out their tasks because of not having equipment but still they are supposed to act professionally in a difficult situation. This may have a strong impact on their morale and, in the long run, result in burnout, decreased job satisfaction, and turnover rates (Sidi and Galadanchi, 2021).

The patients on the other hand are at the mercy of the system. The visit to UBTH could be the first and the last time many of them could get a diagnostic imaging particularly when there are serious cases of illnesses or injuries. There is a delay experienced by such patients when machinery goes down not only contributing to their suffering but also adding to their anxiety as well as frustration. The impact on the patients emotionally can be harsh particularly where an emergency situation would be experienced and the waiting period to get a result of the diagnostic test might postpone the treatment (Ehrlich and Daly, 2009). Delays may prove to be disastrous to those who need emergency treatments. Moreover, patients are already facing the challenge of healthcare expenditures, and there is one more burden on financial resources in case of repeating visits because of equipment failure (Bwanga et al., 2023).

The lack of downtime preventability in most healthcare facilities, including UBTH, is usually due to the following reasons: inadequate maintenance schedules, some technical staff lack training, or the equipment is obsolete and not replaced or repaired as quickly as possible (Adem et al., 2023). A survey of radiology departments in Ghana emphasized the disastrous effect of unaddressed downtime in radiology departments and how many healthcare institutions do not have proactive measures related to providing maintenance on equipment, and their results are frequent system failures that impact service delivery (Adem et al., 2023). Likewise, in Kano, Nigeria, Sidi and Galadanchi (2021) found that failure to have a well-structured maintenance plan and poor technical support were some of the factors that led to long breakage of radiology equipment, which eventually compromised the quality of care.

Besides, the socio-economic elements influencing healthcare facilities in the developing world contribute to the problem. It is a fact that many hospitals work on a tight budget, and the required funds to be used on maintaining and acquiring new equipment are inadequate. In rural or under-served regions, where access to healthcare facilities is compromised, equipment downtime may be even more heightened with even more severe effects on the patients who lack any other source of care (Bwanga et al., 2023). The lack of resources in these environments coupled with an inadequate healthcare planning creates a vicious cycle of failed equipment, late diagnosis, and worsening health outcomes in patients (Ng'andwe & Bwanga, 2022).

Since X-ray services are of utmost importance in the diagnostic process, the problem of the downtime can not be considered only as a technical problem, but as an essential healthcare concern. The long-term implications of equipment unavailability may have a ripple effect on the whole hospital system not only to the patients and the healthcare workers, but also to the image and the work performance of the healthcare establishment in question. The problem presented in this study requires urgent resolution of hospital administrators, leaders of radiology departments, and policymakers alike (CADTH, 2020).The present research will seek to uncover the level of impact of X-ray downtimes at UBTH, in particular, the impact that the issue imposes on patients. It will also explore the reasons behind the downtime as well as delays and disruption of patients and the overall operational issues that the hospital was exposed to. Through the exploration of these spheres, this study aims at making a contribution to the formulation of feasible solutions to enhancing the quality of diagnostic imaging services in UBTH and other institutions of the same kind. It is hoped that through this study, the findings will help inform the better approaches of management, improve the support systems among the staff, and invest more in infrastructure to reduce the impact of equipment downtime. Such gains might dramatically benefit patient care, working conditions of radiographers as well as increase the overall quality of healthcare in the long run.

1.2 Statement of the Problem

Medical imaging, especially X-ray investigations is becoming an essential component in the diagnosis, planning, and follow-ups of patients in the current healthcare environment. It has been unfortunate that in most health institutions, particularly in resource strained environments, the high levels of frequent and even extended X-ray equipment downtimes have become a common and highly frustrating challenge. It is not just a technological recession that it is a people problem that affects the care giving process, the morale of the medics and health of the patients. The after-effect of the X-ray machines whenever they fail or when they are out of service during a prolonged period of time are profound and immediate.

Take the case of a trauma situation where the count of seconds is important, yet the X-ray unit is not operational and as such, no imaging services are availed. They are not just inconveniences on the operations but they may be life and health risks. This inefficiency normally affects the patients who are the most vulnerable stakeholders in this chain. They are even recommended to wait hours, days or even travel long distances to access X-ray services outside. These inconveniences can lead to anxiety, late diagnosis, increased medical costs and in some cases, poor health outcomes. The inability to access the timely diagnostic services might be the deciding factor between an early intervention and the irreversible development of the disease to numerous individuals particularly in the low-income environment.

What is even more complicated about this problem is that it is usually deep-seated into the work of a system: absence of routine maintenance, insufficient technical support, outdated equipment, inadequate financing, and delays in the administrative process. Consequently, this leads to a vicious cycle where machines become damaged, services disrupted, patients will suffer, and staff morale will reduce. However, even though these events are quite common and severe, this issue is frequently underreported and under-studied, in particular, in most developing states. It is thus high time that the actual implications of X-ray equipments downtime be explored and known not only in numerical terms or technical numbers, but in human terms; how it affects the radiographers handling the machines, the staffs who rely on prompt diagnostics, and the patients whose health results are sometimes directly reliant on the effectiveness of radiology departments.

1.3 Research Questions

1. What are the major causes and frequency of X-ray equipment downtime?

2. How does X-ray equipment downtime affect radiographers' workflow and morale?

3. In what ways does equipment downtime impact patient care and satisfaction?

1.4 Research Hypothesis

Null Hypothesis (H_0): There is no significant relationship between X-ray equipment downtime and the quality of patient care or radiographers' workflow.

Alternative Hypothesis (H1): There is significant relationship between X-ray equipment downtime and the quality of patient care or radiographers' workflow.

1.5 Aim and Objectives of Study

1.5.1 Aim of the Study

To assess the causes, frequency and effects of X-ray equipment downtime on patients in selected healthcare facilities.

1.5.2 Objectives of the Study

1. To identify the causes of X-ray equipment downtime.
2. To identify the frequency of X-ray equipment downtime.
3. To examine how equipment downtime affects patient care and service delivery.

1.6 Significance of the Study

This research can be of tremendous importance at various levels, because it addresses an essential but under-researched problem in healthcare delivery X-ray equipment failures. The lessons learned about this study are useful to not only radiographers, but also the whole health sector, the society in general and decision-makers in healthcare policy and infrastructure.

To the Health Sector: Knowledge of the impact of equipment downtime will be the basis of enhancing the performance of service delivery in diagnostic imaging. Early radiographic testing is the key to proper diagnosis and treatment procedures. This study might contribute to improving maintenance procedures in healthcare institutions by emphasizing the operational changes related to machine downtimes, investing in contingency plans, and the sustainability of care, particularly in emergency situations and vital cases.

To Radiography and Radiographers: Radiographers are the silent heroes in a medical institution, the ones who work behind the scenes. The research has allowed them to be heard and their plight has been shown to affect workflow, job satisfaction, morale and professional development through the failure of equipment. The results can be used as a testimonial to restrict the demands of higher standards of work, infrastructure, and special attention to radiographers, which will eventually result in better work and health.

To the Society: The end-users of the healthcare services are patients and the general population and they directly suffer the prolonged delays in diagnosis caused by equipment failure. This research creates awareness of how apparently so-called technical problems can relate to actual outcomes to the individual and community in terms of prolonged illness, increased health expenditure, emotional strain, and deaths that are avoidable. The study may also be used to sensitize the society on the need to invest in and maintain health technologies as a collective social role.

To Policy Makers and Health Administrators: This is one of the most useful additions of the study which could be applied to the formation of an evidence-based policy. Healthcare planning and administration decision-makers require unambiguous and statistically supported knowledge about the role of equipment reliability in service quality. Findings of this work can lead to budgetary allocations, the growth of the infrastructure, the policy of purchases, and the support system. It can also affect national and institutional policies of radiology services, particularly in low resource environments where each machine matters.

1.7 Delimitation of the Study

The scope of this research is the Radiology Department of the University of Benin Teaching Hospital (UBTH) with a particular department that is the X-ray unit. It will only evaluate the impact of equipment downtime in this modality. This study does not include other imaging units like CT, MRI, ultrasound and fluoroscopy.

The study also restricts itself to patients that come in direct contact with X-ray service at UBTH. The research does not go as far as technical or biomedical engineers or assess the mechanical or electrical flaws. It rather focuses on the operational, professional, and emotional effect of downtime on the delivery of healthcare and the workflow of staff in the set range.

1.8 Operational definition of Terms.

X-ray Equipment Downtime: This is a condition when the X-ray machine is not in operation or available to serve the clinical needs of the patient because of a mechanical breakdown, maintenance, or technical problem, and thus the imaging services are interrupted.

Workflow: This is the systematic series of operations and procedures performed by radiographers and other staff in the imaging department during normal operations.

Patient Care: The services provided to patients during their interaction with the radiology department, including the timeliness, efficiency, and satisfaction with imaging services.

Downtime Effects: The consequences or impact of equipment unavailability on radiographers' productivity, patient satisfaction, diagnostic delays, and overall healthcare service delivery.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Brief History of Xray

In the 1870s and 1880s, research involving electricity was the cutting edge of physical science, and many physicists were experimenting with a device called a Crookes tube, a cathode ray tube that was the forerunner of the fluorescent lamp and the neon sign. Although Crookes tubes also produced x-rays, no one detected them. Then, on November 8, 1895, Wilhelm Conrad Roentgen, a German physicist, was working with a Crookes tube at the University of Wiirzburg.

In his darkened laboratory, he enclosed the tube with black photographic paper so that no light could escape. Across the room, a plate coated with barium platino- cyanide crystals, a fluorescent material, began to glow. Roentgen noted that the plate fluoresced in relation to its distance from the tube, becoming brighter when the plate was moved closer. He placed various materials, such as wood, aluminum, and his hand, between the plate and the tube, noting variations in the effect upon the plate. He spent the next few weeks investigating this mysterious energy that he called "x ray," x being the symbol for the unknown. By the end of the year, Roentgen had identified nearly all of the properties of x-rays known today. He was awarded the first Nobel Prize in physics in 1901 in recognition of his discovery.

2.1.2 Principle of Xray Production.

There are four basic requirements for the production of x-rays:

1. A vacuum

2. A source of electrons

3. A target for the electrons

4. A high potential difference (voltage) between the electron source and the target .

The container for the vacuum is the x-ray tube itself (Fig. 1.0), sometimes referred to as a "glass envelope." It is made ofborosilicate glass (PYREXTM) to withstand heat and is fitted on both ends with connections for the electrical supply. All of the air is removed from the tube so that gas molecules will not interfere with the receptor. process of x-ray production.

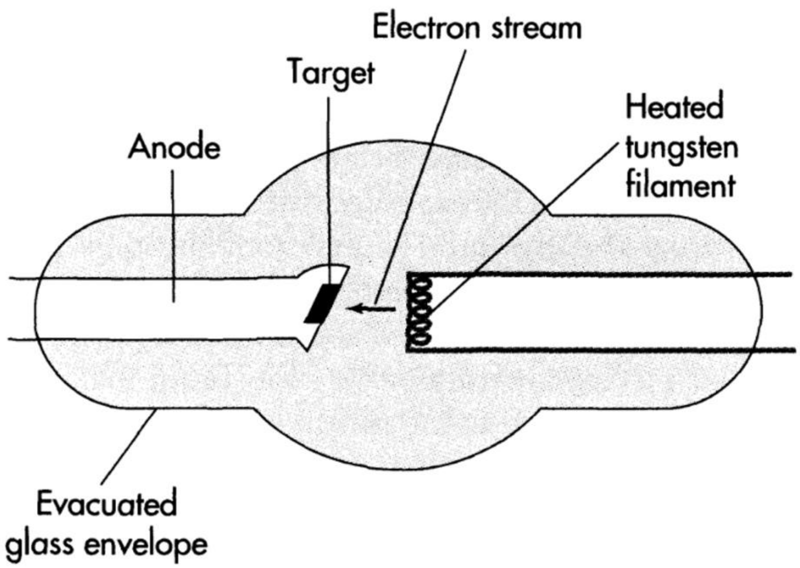


Fig1.0 the glass envelope.(Christie, et al., 2006).

The process of generating X-rays begins at the negative end of the tube, called the cathode, which houses a tungsten wire filament. Tungsten is used because it's a large atom (74 electrons) with a high melting point, making it durable.

To create the necessary supply of electrons, an electric current is passed through this filament to heat it up. As the wire gets hotter, the electrons orbiting the tungsten nuclei move faster and farther away. Eventually, the electrons in the outermost shells break free from their orbits and are effectively "flung out" of the atoms. This process creates a thick cloud of electrons, or space charge around the filament, which gives the X-rays the free electrons that are required to generate X-rays.

The other end of the tube is the positive anode which carries the target. It is also tungsten and this hard, smooth target surface is essential to resist the heat generated in the process which is intense.

A large electrical potential is then supplied by a high-voltage transformer. This voltage is required to keep the cathode as negative as possible and the target (anode) as positive as possible. The strong positive charge of the target then powerfully attracts the free negative electrons from the space charge.

These attracted electrons accelerate rapidly across the tube, forming a high-speed electron stream. When this stream violently collides with the tungsten target, the electrons' kinetic energy has to be converted into other forms of energy. While the vast majority of this energy (over 99%) is immediately converted into heat, a tiny, critical fraction is transformed into the energy known as X-rays.

X-rays are among several types of energy described as electromagnetic energy, or electromagnetic wave radiation. They have both electrical and magnetic properties, changing the field through which they pass both electrically and magnetically. The changes occur in the form of repeating waves known as sinusoidal waves.

Several characteristics of this waveform are significant. The distance between the crest and valley of the wave (its height) is called the amplitude. More important to radiographers is the distance from one crest to the next, or wavelength . The frequency of the wave is the number of times per second that a crest passes a given point. Because all electromagnetic energy moves through space at the same velocity, approximately 186,000 miles per second, which is 30 billion (3 x 10l0) centimeters per second, it is apparent that a relationship exists between wavelength and frequency. When the wavelength is short, the crests are closer together, so more of them dl pass a given point each second, resulting in a higher frequency. Longer wavelengths will have a lower frequency.

This may be expressed mathematically as follows: Velocity (v) =Wavelength (X) x Frequency (f) The more energy the wave has, the greater will be its frequency and the shorter its wavelength. We can therefore use either wavelength or frequency to de- scribe the energy of the wave. In radiologic science, wavelength is more often used to describe the energy of the x-ray beam. The average wavelength of a diagnostic x-ray beam is approximately 0.1 nanometer, which is 10-lo (0.0000000001) meters, or about a billionth of an inch.

The wavelength of electromagnetic radiation varies from exceedingly short (shorter than that of diagnostic x-rays) to very long (more than 5 miles). This range of energies is known as the electromagnetic spectrum. It includes x-rays, gamma rays, visible light, microwaves, and radio waves. Radiation with a wavelength shorter than one nanometer (1O-y meters) is said to be ionizing radiation because it has sufficient energy to remove an electron from an atomic orbit. X-rays are one type of ionizing radiation. The smallest possible unit of electromagnetic energy (analogous to the atom with respect to matter) is the photon, which may be thought of as a minute "bullet" of energy. Photons occur in groups or "bundles" called quanta (singular, quantum).

2.1.3 Radiographic Equipment.

X-ray rooms vary in design, depending on their purpose. For example, a room dedicated to upright chest radiography might not have an x-ray table because the patients in this room would be standing for their examinations, not lying down. A room designed for doing gastrointestinal examinations would be equipped for both radiography and fluoroscopy. A typical room designed for general radiography is suitable for many different types of x-ray examinations. In a hospital setting, the room will be fairly large, perhaps 18 x 20 feet in size, with wide doors to accommodate hos- pital beds and stretchers. Physical features will include the radiographic table, the x-ray tube and its support system, an upright IR cabinet against one wall, and a shielded control booth that contains the control console.

The x-ray tube.

The x-ray tube is the source of the radiation. Modern multipurpose x-ray tubes (Fig.1.1) are dual focus tubes. Their cathode assemblies contain two filaments, one large and one small . Each is situated in a focusing cup that directs its electrons toward the same general area on the target portion of the anode. When the small filament is activated, its electrons are directed to a tiny focal spot on the target. The small filament and focal spot provide finer image detail when a relatively small exposure is appropriate, for example, when imaging a small body part such as a toe or wrist. The large filament provides more electrons and is aimed at a larger target area.

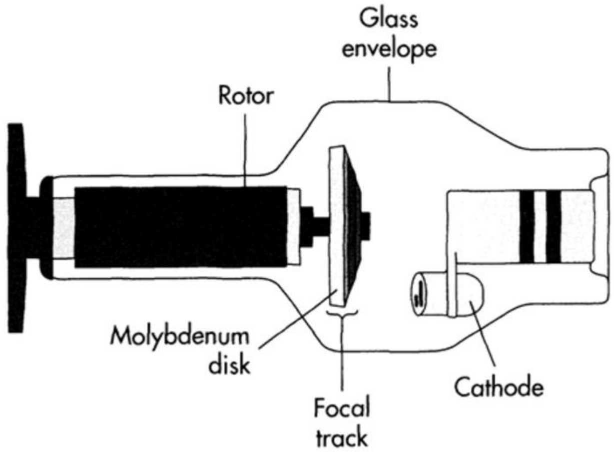


Fig 1.1 the X-ray tube and it's component. (Christie, et al., 2006).

The combination of large filament and large focal spot is used when a large exposure is required, such as for radiographs of the lumbar spine or the abdomen, because the large filament provides more electrons and the large focal spot can better handle the resulting heat at the anode. The anode is disk-shaped and rotates during the exposure (Fig. 1.2), distributing the anode heat over a larger area and increasing the heat capacity of the tube. It is the rotation of the anode that causes the whirring sound just before and after the exposure.

Fig1.2 the disk shaped rotating anode. (Christie, et al., 2006).

X-ray tube housing.

The x-ray tube is located inside a protective barrel-shaped housing (Fig.1.3).The housing incorporates shielding that absorbs radiation that is not a part ofthe useful x-ray beam. The housing protects and insulates the x-ray tube itself while providing a base for attachments that allows the radiographer to manipulate the x-ray tube and to control the size and shape of the x-ray beam.

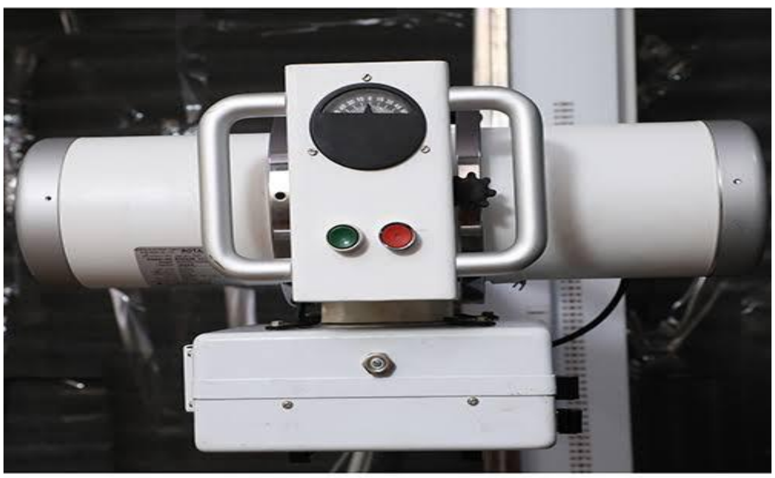


Fig 1.3 the X-ray tube housing. (Christie, et al., 2006).

X-ray tube support

According to Erliich and McCloskey (1988), “The tube housing may either be attached to a ceiling- mount tube hanger or mounted on a tube stand. Both types of mountings provide support and mobility for the tube”. A tube hanger (Fig1.4) is suspended from the ceiling on a system of tracks to allow positioning of the tube at locations throughout the room. This ceiling mount is useful when positioning the tube over a stretcher or when moving the tube for use in different locations. A tube stand (Fig. 1.5) is a vertical support with a horizontal arm that supports the tube over the radiographic table. The tube stand rolls along a track that is secured to the floor (and sometimes also the ceiling or wall), permitting horizontal motion. A system of electric locks holds the tube support in position. The control system for all, or most, of these locks is an attachment on the front of the tube housing. To move the tube in any direction, the locking device must be released. Moving the tube without first releasing the lock may damage the lock, making it impossible to secure the tube in position.

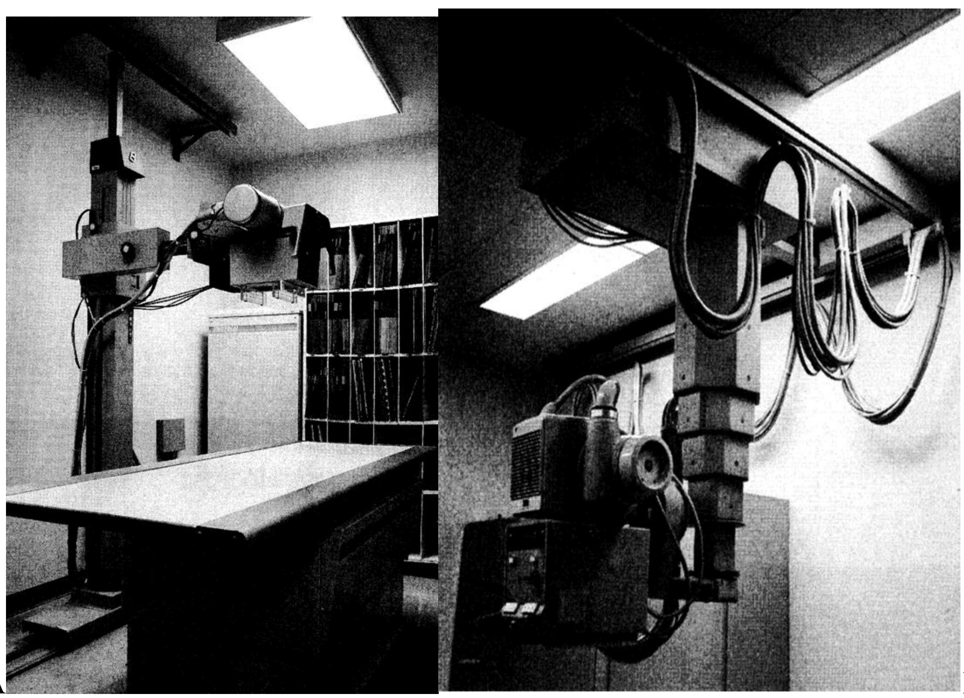
A  B

Fig1.4 both floor mounted tube support(A) and ceiling mounted tube support(B). (Christie, et al., 2006).

Collimator

Another attachment to the tube housing is the collimator, a boxlike device mounted beneath the port, the opening of the housing. Collimators allow the radiographer to vary the size of the radiation field and to indicate with a light beam the size, location, and center of the field. There is usually a centering light that also helps align the IR. Controls on the front of the collimator allow the radiographer to adjust the size of each dimension of the radiation field. The collimator has a scale that indicates each dimension of the field at specific source-image distances. A timer controls the collimator light, turning it off after a certain length of time, usually 30 seconds. This helps to avoid accidental overheating of the unit by prolonged use of its high-intensity light. While many collimators are manually controlled as described in the preceding paragraph, some are equipped with a feature called positive beam limitation (PBL). These collimators have sensors that detect the size of the IR. Some automatically adjust the radiation field size to the size of the IR; others prevent exposure until the field has been manually adjusted to the size of the IR or smaller.

These PBL devices were legally required, for reasons of radiation safety, to be installed on machines manufactured, moved, sold, or significantly upgraded during the years between 1970 and 1993. This requirement no longer exists, but many collimators with PBL features are still in use.

Radiographic table.

The radiographic table is a specialized unit that is more than just a support for the patient. While the table is usually secured to the floor, it may be capable of several types of motion: vertical, tilt, and "floating" tabletop.

As described in “Patient care in Radiology” by Erhlich and McCloskey(1988): “For vertical table motion, a hydraulic motor, activated by a hand, foot, or knee switch, raises or lowers the height of the table. This allows lowering of the table so that the patient can sit down on it easily and also permits the table to rise to a comfortable work- ing height for the radiographer. Adjustments to exact stretcher height can be made to facilitate patient transfers. There will be a detent or standard position for routine radiography. This standard table height corresponds to indicated distances from the x-ray tube. Because it is important that standard tube/IR distances be used, it is necessary to return the table to the detent position after lowering it for patient access. Not all tables are capable of vertical motion.”

Radiographic tables are engineered to provide flexible patient positioning through two main features: tilting and floating tabletops.

Tilting Tables

Tilting tables apply a hydraulic motor to rotate the patient table on a central axis, and positioning at any angle between horizontal and vertical. The feature is important in numerous fluoroscopic operations. It is also possible to tilt the table to elevate the flow of the head of the patient below the legs, which is referred to as the Trendelenburg position (at least 15degrees in general). To work with the table in the horizontal plane, a detent mechanism is used.

The most important thing to take into consideration when using this feature is the safety. Shoulder guards and footboards are important appendices that should be fastened to avoid slipping of patients during tilting. Before the use of the attachments, technologists are required to check the attachment mechanisms. Moreover, the tilt motor is very strong and thus, the personnel should make sure that the space below the two ends of the table is empty of any mobile equipment (including step stools) prior to switching on to avoid damaging the equipment or the motor itself.

Floating Tabletops

Floating tabletop is a choice that offers flexibility in the positioning of patients as it means that the tabletop surface can move independently of the table base. Such movement is critical in ensuring that the patient and the X-ray tube as well as the image receptor (IR) are perfectly aligned. This movement can be done either through a mechanical release which needs to be manually shifted by the radiographer or through a more prevalent power-assisted movement which is activated by a directional switch pad, specifically on the fluoroscopic tables.

Scatter Radiation Control.

Scatter radiation is major problem in radiography since it mainly occurs in the patient during an X-ray exposure. This radiation deteriorates the quality of images by forming an overall exposure in the image, referred to as fog, which hides the minute details of the anatomical structures. Devices like grids and Buckys are used to ensure that the image remains clear and this is because they absorb the scatter radiation, which can otherwise reach and spoil the image receptor.

Bucky grid

A bucky is usually located beneath the table surface. It is a moving grid device that incorporates a tray that holds the IR . The entire unit can be moved along the length of the table and locked into position where desired. The grid that is incorporated into the bucky device is situated between the tabletop and the IR. It is a plate made of tissue-thin lead strips, mounted on edge, with radiolucent interspacing material . The strips must be carefully aligned to the path of the primary x-ray beam, so precise alignment of the x-ray tube is essential. In most radiographic units, the grid moves during the exposure.

The purpose of moving the grid is to blur the image of the thin lead strips so that they are not visible on the radiograph. When the table has a floating tabletop, the bucky mechanism and IR tray do not move with the tabletop.

Stationary grids that do not move during the expo- sure serve the same purpose as a bucky. A grid may also be incorporated into a device called a grid cap, which is a grid mounted in a frame that can be attached to the front of an IR for mobile radiography and other special applications. Grids or buckys are generally used only for body parts that measure more than 10 to 12 cm in thickness.

Transformers

Cables from the tube housing connect the x-ray tube to the transformer, which provides the high voltage necessary for x-ray production. Some transformers look like a large box or cabinet, which may or may not be located within the x-ray room. Newer transformer designs are much smaller and may be incorporated into the control console.

Control console

The control console, located in the control booth, is the access point for the radiographer to determine the exposure factors and to initiate the exposure.

1. Radiographic control consoles have buttons, switches, dials, or digital readouts for some or all of the following functions:

2. Off/On--controls the power to the control panel

3. mA-allows the operator to set the milliamperage, the rate at which the x-rays are produced; determines the focal spot size

4. kVp--controls the kilovoltage, and thereby the wavelength and penetrating power, of the x-ray beam.

5. Timer--controls the duration of the exposure Mas :some units have an mAs control instead mA and time setting. mAs (the product of mA and time) determines the total quantity of radiation produced during an exposure

6. Bucky activates the motor control of the bucky device so that the grid will move during the exposure Automatic exposure controls (AECs)-special settings available on certain units that allow termination of exposure when a certain quantity of radiation has reached the IR.

7. Meters or digital readouts to indicate the status of the settings.

8. Prep (ready or rotor) switch-prepares the tube for exposure and must be continuously activated until exposure is complete.

9. Exposure switch-initiates the exposure and must be continuously activated until the exposure is complete.

10. Accessories-other controls may also be present, depending on the equipment and its specific features.

2.1.4 X-Ray Equipment Down Time.

Medical equipment downtime can be defined as the time during which medical machines or equipment cannot be utilized because of a malfunctioning, a failure, or any other technical cause. The healthcare organisations are concerned about it as it may result in delayed or interrupted patient care, decreased productivity, high costs, and legal or regulatory consequences.

Medical equipment is important in a healthcare setting as it offers quality care to a patient. Medical devices and equipment play a very vital role in diagnosis and treatment of many medical conditions as well as in management of patients such as premature infants using ventilators and defibrillators among others. The failure or malfunction of such devices can lead to such negative outcomes as missed treatment, misdiagnosis, and even injury to the patient.

Healthcare organisations can also encounter large financial costs as a result of the downtimes of their medical equipment. Downtime may also lead to loss of revenue, maintenance and cost of repairs, and even one may need to buy new equipment as a replacement to faulty equipment.

Taking into consideration the serious impact of the downtime of medical equipment, healthcare organisations need to be proactive in terms of preventing and successfully managing the downtime in case it takes place. The subsequent sections will consider the different factors that may lead to medical equipment downtime, effects of down time, and measures that can be adopted by healthcare organisations to prevent and deal with equipment downtime.

Typical reasons of X-ray equipment outage in Radiology Departments.

Radiological equipment downtime especially the X-ray machine is the time when the equipment is not functioning and can not be used to provide diagnostic services. This is an urgent problem in radiology departments, and particularly in resource-constrained environments, because it causes disruptions in the service, delay in the diagnosis, and workflow strain. This downtime has a number of factors, and it is imperative to know the factors to develop effective interventions.

Human Error - One of the major causes of downtime is the error made by the staff handling and using radiology equipment such as radiographers and technicians. They can be attributed to poor training, carelessness, or lack of observing the standard operating procedures. The wrong use may lead to damage of hardware, miscalibration or lockouts in operation, putting equipment out of commission for the moment or permanently.

Equipment Failure- A very common characteristic of radiology equipment is mechanical failure of equipment used when the equipment is old or in bad condition. Problems with faulty anode motors, broken tube components, broken collimators or rotting transformers may make the X-ray machine unusable and in most cases need special parts or technician labor to fix.

Maintenance and Repairs - Preventive maintenance is scheduled and deal with operational efficiency maintenance. Nevertheless, maintenance in most of the facilities is haphazard or purely reactive. X-ray machines are subsequently serviced, which implies that they will have to be offline, and this inevitably causes downtimes. Maintenance planned in a low resource environment can lead to high-time of equipment unavailability where there could be delays in the delivery of parts or the response of technicians.

Problems with power supply - X-ray machines are very particular to a constant flow of power. Nigeria has a history of frequent blackouts, voltage drops, or damages caused by surges that are inherent in most health care facilities in the country and play a major role in the malfunction of equipment. Machines that lack stabilizers or spare energy will be of particular concern.

Software or System Failures - The recent radiology equipment has digitalized imaging systems and software interfaces. The failure of the firmware update, old software, or corrupted imaging programs may crash the whole unit. Picture Archiving and Communication Systems (PACS) or data storage malfunctions also constitute a problem, and often necessitate the technical intervention that takes a considerable amount of time.

The contributors to equipment down time:

It is significant to identify the factors to ensure that effective strategies are developed to prevent and handle medical equipment downtime, healthcare organisations have to identify the factors that can cause downtime first. The following are some of the factors that should be considered:

Age: Equipment can become worn out and its performance or failures can come about as a result of constant use as it gets old.

Poor Maintaining: Inefficient or poor maintenance may lead to equipments failure or breakdown. This may encompass the problem of not replacing the parts that are worn or missing scheduled maintenance.

Environmental Factors: The environmental factors, that is, the temperature, humidity, dust and other contaminants depending on the kind of medical equipment, may lead to malfunction or collapse of the equipment. This may be of particularly worrying concern when it comes to delicate equipment like MRI machines or ventilators.

Power Interruptions: Power interruptions or variations may destroy equipment or lead to its failure. Gadgets that are dependent on constant power supplies like lasers or imaging devices are highly prone to such an anomaly.

User Error: due to improper training or usage, equipment may malfunction as well as break down.

Software and Firmware Problems: There can be period of downtime in Medical equipment because of its software or firmware problems, including bugs, glitches, or compatibility problems with other systems.

Upgrades and Modifications: Upgrades or a modification of equipments can be also a cause of a downtime, because new software or hardware can be needed to be installed and compatibility is a problem that may occur. This may be alarming especially to old equipment that might not be compatible with the new systems or software.

2.1.5 Impact of Equipment Downtime on Healthcare And Financing

The failure of medical equipment can contribute greatly to the productivity and financial welfare of healthcare organisationsThe delay in the diagnosis and treatment process may be caused by the failure of medical equipment and will result in the prolonged hospitalization and quality care.

Downtime may cause decreased productivity by the healthcare providers since they might have to wait until machines have been repaired or replaced to resume their duties. It may cause higher labour expenses and work overload, which will also affect patient care.

Health care organisations can also incur additional rates of maintenance and repair and also lost revenue because of cancelled appointments or procedures. The faulty equipment might also require replacement in certain instances subjecting the company to more capital expenditure.

Healthcare organisations need to adopt good maintenance and repair processes, invest in quality equipment and establish contingency measures to faulty equipments. This way, they will reduce the adverse effects of downtime on their operations, finances, and patients due to the medical equipment.

2.1.6 Eliminate Equipments Downtime.

Healthcare organisations can use a number of measures to avoid downtime of medical equipment, which includes:

1.Adoption of preventive maintenance program, in order to detect and solve possible medical equipment problems. Regular maintenance inspections, cleaning, calibration and replacement of worn or damaged parts can be part of the preventive maintenance program.

2.Giving the staff personnel sufficient training on the use and maintenance of equipment to avoid user error and minimize the chances of equipment malfunction.

3.High-quality medical equipment can also be invested in to minimize the chance of downtime as a result of equipment failure. Quality equipment is more dependable and is more durable and has a high maintenance rate.

4.Checking of environmental conditions like temperature, humidity, and air quality to avoid malfunction of the equipment because of environmental conditions.

5.Setting up redundancy like backup equipment or the contingency plan to make sure that the care to the patients is not affected in the case of a medical equipments failure.

6.Regular equipment audits in order to determine equipment that is likely to fail and may require replacement or repair.

2.2 Empirical Review

A number of empirical studies have examined the effects of equipment downtime and difficulties in service delivery in radiology departments particularly in the developing nations. Some of the challenges that have been pointed out in these studies include numerous equipment failures, inadequate maintenance and unequal distribution of imaging resources.

In the research by Sidi and Galadanchi (2021), a retrospective study was conducted in Kano, Nigeria, to determine the downtime of radiological equipment in the selected hospitals. The study reported a high number of radiological equipment that had extended downtimes. As an example, an angiography department showed a downtime of two years and eight months, and the X-ray and CT machines had also a great service interruption. The research reached a conclusion that the culture of poor maintenance and ineffective infrastructure was one of the biggest contributors of equipment breakdown.

Radiology equipment units of three teaching hospitals were reviewed by Adem et al. (2023) in a similar study in Ghana. They complained that there were frequent breakdowns and long downtimes that seriously interfered with the clinical services. In the study, the researcher observed that the company lacked post-installation training and maintenance contracts which enhanced the inefficiency of the operational processes. The financial repercussion was also very high as it is estimated that there was a loss of approximately US 1.97 million because of loss of services in one year.

Ng’andwe and Bwanga (2022) examined some of the factors that influence radiographers in rural Zambia. Their qualitative analysis revealed outdated and aging equipment, slow procurement procedures, and non servicing as the significant problems. Such conditions reduced the capacity of radiographers to offer consistent imaging services. Another aspect of the study that was brought into limelight was the fact that majority of the imaging machinery and professionals are concentrated in the urban regions leaving rural communities underserved.

Another study on mobile radiography services concerned Zambia (Bwanga et al., 2023). The researchers concluded that although the mobile radiography is increasingly in demand, the amount of operating mobile X-ray machines is insufficient. Among 16 machines that existed in 17 hospitals, some of them were not operational because of either unserviceability or unavailability of spare parts. As highlighted in the review, an investment in digital mobile X-ray units and frequent servicing should be done to aid bedside X-ray imaging in critical care units.

At the larger level, the CADTH (2020) reviewed the effect of various forms of maintenance service agreements (MSAs) in Canada on the downtime of the equipment. It was revealed in the study that facilities with full vendor service agreements had less downtimes as opposed to in-house and shared services. Indicatively, the CT units under vendor agreements had on average of 42 hours of downtime per year as compared to the in-house agreements that had more downtime. The results indicate that maintenance organized plans have a considerable potential to decrease the number of equipment failures and enhance service delivery.

In order to study the management policies, which affect the operational effectiveness, Ekpo et al. (2013) conducted an in-depth assessment of the spread of radiological equipment in nine hospitals located in the north of Nigeria. The study found out that only two hospitals had fully furnished radiography departments; most of them had adequate planning and maintenance systems. Particularly 16% of the equipment was found to be out of action; minor faults led to 48 hours of non-functionality and major faults led to two months. It was reported that lack of end-users input in the procurement process, the absence of preventative maintenance, and an ineffective quality control policy were major causes of equipment inefficiency. Among the hospitals, 22 percent implemented the scheduled preventative measures; 78 percent did not, and as a result, the equipment malfunctioned and the service was interrupted.

In a similar national survey, Okeji et al. (2012) examined procurement and management policy in 13 radiology centres that were spread throughout Nigeria. They have found that the real end users, radiographers, were not incorporated in the procurement planning in 85% of the reviewed universities. No one of the two hospitals had the preventive maintenance organised, only two of them had some sort of quality assurance efforts. Ordinary failures in equipment also took 2-8 weeks to address and big problems took between 2 months and about one year. The researchers related longer downtime to poor planning, absence of technical consultation and ignoring of preventive measures. They emphasized that without the equipment acquisition according to the needs of the department and the active maintenance of the quality assurance measures, the functional radiology services can be promoted only. These findings prove that equipment downtime in the radiology departments across the entire Nigeria is a systemic issue. Among the urban and rural institutions, lack of user input in the acquisition process, inadequate or absence of maintenance systems and neglect of quality can be common.

The suggestion is not just regular service interruption but also diminishing patient trust, higher expense of treatment, and impaired diagnostic accuracy. Ensuring sustainable diagnostic imaging services depends on including radiographers in procurement choices and combining preventive maintenance initiatives.

These studies demonstrate that effective maintenance planning, proper resource distribution, and technical support are essential for sustaining radiology services. In low-resource settings, the lack of these components continues to hinder efficient healthcare delivery, especially in rural and underserved areas.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Setting

This study was carried at the University of Benin Teaching Hospital, which is a tertiary healthcare center in Benin City, Nigeria. UBTH is a leading health care institution which offers a wide range of services, such as diagnostic imaging, to a wide range of population. The UBTH radiology department has a X-ray machine that is utilized to carry out different diagnostic processes. Since the radiology facility is an important department in the diagnosis and treatment of patients, the facility would be a perfect place to conduct research on the effects of equipment downtime. This research will be done on the impact of downtime on the functions of the radiology unit and the experiences of the radiographers and patients affected by such delays.

3.2 Research Design

The research design used in the study was descriptive cross-sectional. This design was appropriate to give a picture of the prevailing state of affairs at UBTH in relation to equipment downtime and its impacts. It was also possible to collect data on a sample of a patients at one point at a given time to reveal patterns and relationships without manipulating the study variables. This design came in handy especially in studying the perception and experiences of participants with regards to the downtime of X-ray machine..

3.3 Target Population

The study population was a group of patients in UBTH that has first hand or indirect experience with X-ray equipment downtime. The sample population involved those patients who either have or are to receive diagnostic imaging services at UBTH and had to wait because of equipment inactivity. These patients presented an insight on the effect of delays in their medical care, diagnosis and their experience with healthcare services in general.

Inclusion Criteria

Participants must:

1.Be of age 18 years and above when study is done.

2.Are patients with diagnostic imaging with ionizing radiation (e.g. X-ray, CT) at the University of Benin Teaching Hospital (UBTH).

3.be aware and mentally awake, and able to make an informed consent.

4.Be ready to take part in the study on a voluntary basis and answer the questionnaire.

5.Can speak or write, in English (with little assistance).

Exclusion Criteria

The participants were not allowed to participate when they:

1.Critically ill or unconscious, and mentally incapacitated, so that they are unable to make informed consent or fill in the questionnaire.

2.Experiencing non-radiation imaging protocols (e.g. ultrasound, MRI).

3.Refuse to take part or to make withdrawal at any stage.

4.Repeat respondents (the first-only will be utilized).

3.4 Technique of Sampling and Sample Size.

This was a census sampling study. This strategy is used on the whole population of interest as opposed to a subset. In this instance, every patient (200) who had waits in accessing diagnostic imaging because of loss of x-ray equipment throughout the period of study was considered. Census sampling provides a broad coverage of the target population, which includes the full set of patient experience and medical conditions influenced by equipment downtimes. By incorporating all the qualified patients the study will have more precise and generalized results on the effects of the x-ray equipment downtime on the diagnostic imaging services.

3.5 Instrument of Data Collection

The structured questionnaire was used to collect data that was in both quantitative and qualitative form. A questionnaire was prepared in a structured format where the questionnaire questions were prepared in a way that they were clear and standardized so that analysis of the data was easy. The following sections were split into the questionnaire:

Demographic Data: The section gathered data about the age of the participants, gender, and the type of experience of the participants with equipment downtime.

Equipment Downtime Perceptions: This section evaluated the perceptions of the participants on the frequency, causes and effects of equipment downtime. The queries were based on the experiences with delays and how it impacted their medical care.

Effects of Downtime: In this section, the issue of equipment downtime was evaluated on the emotional, professional, and care delivery levels of the participants. It studied the impact of the delay in imaging on their diagnosis and treatment as well as emotional health.

3.6 Validity of Instrument

Content validity and face validity were used in ensuring the validity of the instrument. The content validity was determined by making the experts in the areas of radiography to review the questionnaire and my supervisor to ensure that the questionnaire is able to capture the important factors of equipment downtime and the impact. The face validity was evaluated by asking a small sample of radiographers and patients to read the questionnaire and give the feedback concerning the sensibility of the questions and their applicability in their experiences. The revisions required to enhance the validity of the instrument shall be done based on the feedback.

3.7 Reliability of Instrument

The instrument was tested regarding its reliability with the help of a pilot test on a small group of 20 patients at RayTouch that were not part of the main study. The pilot study assisted in establishing the conditions of any ambiguity in the questionnaire and to make some revision. In order to determine the internal consistency, the alpha coefficient was determined using the Cronbach method with the Likert-scale items. The value of alpha obtained was 0.8 that reflected an acceptable reliability. Before the main study, the identified issues were tackled in the pilot study, and then data collection was done.

3.8 Method of Data Collection

The questionnaires were given to the sampled patients at UBTH. The patients were requested to fill the questionnaire in the waiting rooms or during the waiting period before being subjected to the imaging test. Follow up was made after the first round of distribution of questionnaires that were not completed at the time so that all the questionnaires are returned within the given time. Any blank or unclear answers was made clear with the participants.

3.9 Method of Data Analysis

Both descriptive and inferential analyses were used to analyze the data. The demographic characteristics of the participants and their response to the questions related to equipment downtime were summarized using descriptive statistics, including frequencies, percentages and means. To establish whether there are any significant associations between downtime experiences and the demographics of the participants, chi-square was used.

3.10 Ethical Considerations

Ethical approval for the study was obtained from the Ethics Committee of the University of Benin Teaching Hospital (UBTH). The study adhered to ethical guidelines for conducting research involving human participants, which includes informed Consent, confidentiality, minimization of Harm of participants. In addition, all data was stored securely and only accessible to authorized researchers.

CHAPTER FOUR

DATA PRESENTATION AND DISCUSSION OF FINDINGS

4.1 Data Presentation

Table 4.1a Demographic Information (N = 200)

Variable	**Frequency (n)**	**Percentage (%)**
Age Group		
18–25	17	8.5%
26–35	87	43.5%
36–45	28	14.0%
46 and above	68	34.0%
Total	200	100.0%
Gender		

Male	92	46.0%
Female	108	54.0%
Total	200	100.0%

From table 4.1a majority of the respondents (43.5%) were between the ages of 26–35 years and majority of the respondents were female (54.0%).

Table 4.1b Demographic Information (N = 200)

Variable	**Frequency (n)**	**Percentage (%)**
Ever undergone an X-ray examination at UBTH		
Yes	157	78.5%
No	43	21.5%
Total	200	100.0%
Delay in X-ray appointment due to equipment failure		
Yes	112	56.0%
No	88	44.0%
Total	200	100.0%

From table 4.1b majority of the respondents (78.5%) had undergone an X-ray examination at UBTH. Also majority (56.0%) of the respondents experienced a delay in their X-ray appointment due to equipment failure.

Objective 1: To Identify the Causes of X-ray Equipment Downtime

Table 4.2: Perceived Causes of Equipment Downtime (N = 200)

Statement	SA(%)	A(%)	N(%)	D(%)	SD(%)	Mean ± SD	Decision
Poor maintenance is a major cause of equipment failure	87 (43.5%)	65 (32.5%)	25 (12.5%)	13 (6.5%)	10 (5.0%)	4.03 ± 1.06	Accepted
Power failure contributes to frequent downtime	73 (36.5%)	81 (40.5%)	22 (11.0%)	17 (8.5%)	7 (3.5%)	4.00 ± 1.02	Rejected

Where SA-Strongly Agree, A-Agree, N-Neutral, D-Disagree, SD-Strongly Disagree

Grand Mean: 4.02

Decision Rule: If Mean > Grand Mean → Accepted; If Mean ≤ Grand Mean → Rejected

From table 4.2 only 'poor maintenance' is accepted as a major cause. 'Power failure' is below the grand mean and therefore rejected.

Objective 2: To Identify the Frequency of X-ray Equipment Downtime

Table 4.3: Perceived Frequency of Equipment Downtime (N = 200)

Statement	SA(%)	A(%)	N(%)	D(%)	SD(%)	Mean ± SD
Equipment downtime happens frequently at UBTH	69 (34.5%)	79 (39.5%)	28 (14.0%)	16 (8.0%)	8 (4.0%)	3.92 ± 1.07

According to table 4.3 a total of 74% of respondents (Strongly Agree + Agree) agreed that equipment downtime happens frequently at UBTH, while only 12% disagreed (Disagree + Strongly Disagree). The mean score of 3.92 is close to 'Agree' on the Likert scale, indicating a generally positive agreement. Thus, most respondents perceive that equipment downtime occurs frequently at UBTH.

Objective 3: To Examine How Equipment Downtime Affects Patient Care and Service Delivery

Table 4.4: Impact on Patient Care and Service Delivery (N = 200)

Statement	**SA(%)**	**A(%)**	**N(%)**	**D(%)**	**SD(%)**	**Mean ± SD**	**Decision**
I was asked to return on another day due to X-ray failure	98 (49.0%)	64 (32.0%)	18 (9.0%)	12 (6.0%)	8 (4.0%)	4.08 ± 1.01	Accepted
The delay made me anxious or worried	93 (46.5%)	66 (33.0%)	20 (10.0%)	13 (6.5%)	8 (4.0%)	4.08 ± 1.02	Accepted
The delay affected how fast I got treated	96 (48.0%)	70 (35.0%)	16 (8.0%)	10 (5.0%)	8 (4.0%)	4.18 ± 0.96	Accepted
I felt dissatisfied with the delay in imaging service	91 (45.5%)	65 (32.5%)	20 (10.0%)	13 (6.5%)	11 (5.5%)	4.01 ± 1.08	Accepted
I trust that the hospital is trying its best despite challenges	51 (25.5%)	73 (36.5%)	38 (19.0%)	22 (11.0%)	16 (8.0%)	3.61 ± 1.20	Rejected
I am satisfied overall with the services at UBTH	58 (29.0%)	70 (35.0%)	35 (17.5%)	21 (10.5%)	16 (8.0%)	3.67 ± 1.18	Rejected

Grand Mean = 3.93

Decision Rule: If Mean > Grand Mean → Accepted; If Mean ≤ Grand Mean → Rejected

From table 4.4 based on the grand mean of 3.93, the first three statements had mean scores that met or exceeded this threshold, indicating strong agreement among respondents. This implies that the issue of equipment downtime has a great impact on the patient care through delay, dissatisfaction, and anxiety. Nevertheless, both the final two statement were mean lower than the grand mean implying that there is a relatively lower trust and satisfaction with how the hospital manages equipment downtime.

4.2 Test of Hypothesis

This section presents the statistical test conducted to examine the relationship between X-ray equipment downtime and the quality of patient care. The test was carried out using the Chi-square (χ^2) test of independence at a 0.05 level of significance.

Hypotheses

Null Hypothesis (H 0): X-ray equipment downtime has no significant relationship with the quality of patient care.

Alternative Hypothesis (H1): The quality of patient care has a significant reliance on X-ray equipment downtime.

Table 4.5a: Cross-tabulation of Equipment Downtime and Delay in Treatment

Downtime \ Treatment Delay	**SA**	**A**	**N**	**D**	**SD**
SA	50	45	10	5	2

A	40	35	15	6	4
N	20	15	5	2	1
D	10	8	2	1	1
SD	5	4	1	1	1

Table 4.5b: Chi-square Test Summary

Chi-square Statistic	**df**	**P-value**	**Decision**
92.45	16	0.0000	Reject H_0 (Significant)

The outcome of the Chi-square test (kh2 = 92.45, df = 16, $p < 0.0001$) indicates that the perceived frequency of equipment downtime and delay of patient treatment have a statistically significant relationship. This means that patients who had high incidences of equipment downtime had a very high probability of also reporting treatment delays. The null hypothesis is rejected, as the p-value is smaller than 0.05. Thus, it can be concluded that the relationship between X-ray equipment downtime and quality of patient care at UBTH is significant.

4.3 Discussion of Findings

Objective 1: To Identify the Causes of X-ray Equipment Downtime

Results of the question posed in Table 4.2 indicated that most respondents cited poor maintenance and power failure as the major causes of the X-ray equipment downtime at the radiology unit within the UBTH. Particularly, 43.5% strongly agreed and 32.5% agreed that poor maintenance was a significant cause with a mean score of 4.03 +- 1.06 exceeding the grand mean

(4.02) hence being accepted. Power failure on the other hand, though admitted by 36.5% of the respondents as a major cause, had a mean score of 4.00 +- 1.02, which was not much higher than the grand mean, and was therefore rejected.

These findings indicate that the respondents consider poor technical support and no regular servicing as being the more significant problem than random power supply. This highlights the internal operating issue as opposed to the lack of external infrastructures as the major cause of downtime at UBTH. The X-ray machine, similar to any other radiologic equipment, should be maintained in form of scheduled preventive maintenance, calibration, and timely reaction to failures. Failure to carry out these duties leads to failure in various tasks, long working hours, and disturbance of patient care. This finding pointing out the poor maintenance demonstrates the systemic deficit in the management of equipment lifecycle, which implies the lack of a maintenance contract, ineffective supervision, or insufficiency of funding allocated to servicing.

Sidi and Galadanchi (2021) also confirm this observation by revealing that radiologic equipment in the sampled hospitals in Kano, Nigeria, had long downtimes, which were mainly attributed to ineffective culture of maintenance. Their research reported the cases when the equipment was not functioning during months or years, and the failure was explained by the absence of preventive measures and neglect of infrastructure. Nonetheless, this study compares with the results of Adem et al. (2023) in Ghana, who made it clear that failures related to power, absence of post-installation training were more important than maintenance schedules. In their case, the failure of well-maintained equipment was a common occurrence because of unstable power supply and human mistakes, so infrastructural vulnerabilities may be even more disruptive than the internal servicing problem.

Lastly, although there are various issues that cause equipment downtimes, the current paper identifies poor maintenance as the main factor in the UBTH, although it is a bit dissimilar when compared to other areas of the region where power infrastructure or procurement practice would be a leading issue.

Objective 2: To Identify the Frequency of X-ray Equipment Downtime

Table 4.3 analysis revealed that a significant percentage of the respondents perceived X-ray equipment outage to frequently happen in UBTH. Precisely, 34.5 percent and 39.5 percent strongly and agreed with the statement that equipment downtime occurs on a regular basis and the mean score of 3.92 +- 1.07 was obtained.

This finding means that despite the fact that most of the respondents consider that downtime of equipment is prevalent, the perception is not strong and consistent enough to be cut across all the responses to fit the criteria of acceptance. This may imply differences in the patient experiences or differences in the exposure to the events of equipment breakdowns based on the timing, unit attended, or nature of investigation. What this implies is that that the reality of downtime is genuine but not necessarily understood by all the users as a routine and highly frequent event perhaps because of the recent advances in the servicing schedules, the availability of the backup machines, or maybe even how emergency cases can be given priority and thus lessen patient exposure to delays.

Bwanga et al. (2023) also support this observation by saying that, despite the high demand of mobile X-ray services in hospitals in Zambia, all the available equipment was not regularly out of commission. There were mobile units that worked in some facilities and the downtimes were not constant, and in most cases it was because of unavailability of spare parts or delay in servicing and not because of unending equipment breakdown. This demonstrates that despite the presence of downtime, not all centers have to experience it on a chronic basis. Conversely, the outcome is inconsistent with the results of Ekpo et al. (2013) who noted that in nine hospitals in the north of Nigeria, the downtime was a common and prevalent characteristic of the radiology departments, and the major faults (up to two months) were not addressed by most hospitals. Their results indicate that the rate of breakdowns is considerably larger than that of the patients in UBTH might be these days.

This paper demonstrates that perception of high frequency of equipment downtime does exist, but not strong enough to generalize on the respondent population as a whole to conclude that downtime is a ubiquitous and constant phenomenon at UBTH. This can indicate the variation in the performance of equipment or successful interventions that have minimized the perceived burden with time.

Objective 3: To Examine How Equipment Downtime Affects Patient Care and Service Delivery

Based on the findings outlined in Table 4.4, the respondents showed that the downtime of equipment at UBTH had a distinct impact on patient care and service delivery. First three statements that evaluated issues like getting asked back, anxiety, delay in treatment, and dissatisfaction all stated mean values above the grand mean of 3.93, and were acceptedThis shows that there was a high degree of agreement among participants that equipment low time severely affects healthcare delivery. Particularly, 49.0% of the participants highly concurred and 32.0% agreed that they had been requested to come back on another day because of machine breakdown. Equally, 46.5 percent, and 33 percent respectively accepted that the delay made them anxious and 48.0 percent and 35.0 percent of the respondents agreed that it influenced their speed in treatment. The treatment delay mean score was the highest one (4.18 +- 0.96), which confirms that a service interruption is directly connected to slower care and lower clinical efficiency. These findings explain why there are real psychological and logistical impacts of equipment downtime. Patients do not only experience delays but also feel anxious, dissatisfied, and in other cases, they develop mistrust to the facility. This chain reaction of ill effects demonstrates the impact that technical malfunctions can have on the quality of services in general, despite the presence and readiness of human resources. These results are confirmed by the research conducted by Ng'andwe and Bwanga (2022), who discovered that the delivery of services by radiographers in rural areas of Zambia was hindered by chronic equipment problems. In their research, they stressed that the lack of continuity of the services was due to outdated or ineffective machines, which provoked dissatisfaction and distrust among the rural population. Their setting was rural, but their effects on service delivery are similar to those that were witnessed in the present research at UBTH. Nonetheless, the results are opposite to CADTH

(2020) stating that Canadian centers with full vendor service agreements had negligible downtime and this factor resulted in less patient care disruption. With these well stocked environments, when technical problems crop in, they are attended to as soon as possible and patient care is hardly affected. This implies the consequences of equipment downtime are conditional and stronger when in resource-limiting conditions. In this study, it is evident that any downtime in equipment at the UBTH has a major impact on patient flow, emotional response and the level of satisfaction. These inconveniences do not only slow treatment and diagnosis, but also undermine the general healthcare experience of a patient. Discussing the problem of equipment-related issues, this is not only a technical necessity but also a patient-centered care issue.

CHAPTER FIVE

CONCLUSION, RECOMMENDATIONS AND FURTHER RESEARCH

5.1 Conclusion

In this research it was found that patient flow, emotional response and level of satisfaction are highly influenced by equipment downtime at UBTH. Such disruptions do not only postpone diagnosis and treatment, but also undermine the overall healthcare experience of the patient. The consideration of equipment-related problems, therefore, is not a technical requirement, and it can also impact patient care and service delivery in the University of Benin Teaching Hospital (UBTH) and hence is a matter of patient-centered care. The results showed that poor maintenance was the top reason that resulted in the downtime whereas power failure was not as strongly felt to be a major cause. The impression was not homogenous enough to reach the size of the grand mean even though most respondents concurred that equipment downtime is a frequent occurrence. Nevertheless, it was discovered that equipment downtime has a distinct negative effect on patient care in terms of delaying treatment, dissatisfaction, and anxiety. The hypothesis test showed that there was a statistically significant relationship between the X-ray equipment downtime and patient care quality implying that technical failures in diagnostic imaging have a direct effect on healthcare provision. These findings highlight the role of effective equipment management, preventive maintenance, and proper administration planning in the minimization of downtime and provision of steady radiological services.

5.2 Recommendations

On the basis of the results of the present study, it can be suggested the following recommendations: Introduce a formal preventive maintenance programme: UBTH would implement and follow a regular program of equipment maintenance with vendors or biomedical engineers in order to minimise the number of unforeseen breakdowns. Engage radiographers in purchasing and planning: Radiographers users should also be involved as part of the decision making process involving the purchase and installation of machines to ensure that they are compatible with the needs of operation. Create quick-fix repair policies: A backup technical team must be put in place where quick solutions to equipment errors are made to reduce service unavailability. Routine monitoring and auditing of equipment performance: The hospital is encouraged to maintain records of the use and faults of the equipment to identify trends and to act proactively.

5.3 Suggestions for Future Research.

The following areas can be considered by future researchers:

1. A comparative analysis of the radiology facilities in the private and the public sphere in terms of the equipment downtimes and their impact on the service delivery.

2. 2.A longitudinal survey of the cost consequences of equipment breakdowns on patient flows and departmental income. The multi-center analysis with the participation of various states or regions in analyzing geographical variations of equipment efficiency.

5.5 Limitations of the Study

Scope Limitation: The study was limited to UBTH and may not fully represent the experiences of other hospitals across Nigeria.

Self-reported Data: The data relied on patients' perceptions and may be subject to recall bias or subjective interpretation of delay experiences.

REFERENCES

Adem, B. E., Angmorterh, S. K., Aboagye, S., Agyemang, P. N., Angaag, N. A., & Ofori, E. K. (2023). Equipment downtime in the radiology departments of three teaching hospitals in Ghana. *Radiography,* 29, 833–837.

Bwanga, O., Sindaza, N., Chanda, E., Bwalya, N., Jere, E. C., & Mulenga, J. (2023). Opportunities and Challenges of Mobile Radiography Services in Zambia. *International Journal of Medical Reviews,* 10(4), 616–624.

CADTH. (2020). The Relationship Between Equipment Downtime and Types of Maintenance Service Agreements. *Canadian Medical Imaging Inventory.* Retrieved from: https://www.cadth.ca

Ng'andwe, E. M., & Bwanga, O. (2022). Factors affecting the ability of radiographers to deliver imaging services in rural parts of Zambia. *Radiography*, 28(3), 758–765.

Sidi, M., & Galadanchi, K. K. (2021). Evaluation of the downtime of radiological equipment in Kano Metropolis, Nigeria. *Dutse Journal of Pure and Applied Sciences (DUJOPAS),* 7(3a), 160–167.

Ehrlich, R. A., & Daly, J. A. (2009). Patient care in radiography: With an introduction to medical imaging (7th ed.). *Mosby/Elsevier.*

Medical-Equipment-Downtime.Source:https://softpromedical.com/resources/medical-equipment-downtime/

Ekpo, E. U., Egbe, N. O., Azogor, W. E., Inyang, S. O., & Upeh, E. R. (2013). Challenges of radiological equipment management policies in some northern Nigerian hospitals. The South African Radiographer, 51(1), 19–22. Retrieved from https://www.sorsa.org.za

Okeji, M. C., Onwuzu, S. W., Eze, J. C., & Ayogu, E. (2012). An assessment of equipment procurement and management policies in radiology centres in Nigeria. Journal of the Association of Radiographers of Nigeria, 26, 28–34. Retrieved from https://www.jarn-xray.org

APPENDIX I

X-RAY EQUIPMENT DOWNTIME ON PATIENTS SATISFACTION IN A TERTIARY HOSPITAL IN BENIN CITY

QUESTIONNAIRE

SECTION A: DEMOGRAPHIC INFORMATION

Please tick (✓) the appropriate option.

1. Age:
☐ 18–25 ☐ 26–35 ☐ 36–45 ☐ 46 and above

2. Gender:
☐ Male ☐ Female

3. Have you ever undergone an X-ray examination at UBTH?
☐ Yes ☐ No

4. Did you experience a delay in your X-ray appointment due to equipment failure?
☐ Yes ☐ No

Section B: Frequency and Causes of X-ray Equipment Downtime

1. Have you ever experienced a delay in having your X-ray examination at UBTH?

☐ Yes ☐ No

2. If yes, how often do you experience such delays?

☐ Rarely (once in a long while)

☐ Occasionally (a few times in a year)

☐ Frequently (almost every visit)

3. In your experience, what was usually given as the cause of the delay?

☐ Equipment breakdown/fault

☐ Power supply issues

☐ Shortage of radiographers

☐ Other (please specify) ____________

4. Approximately how long was the longest delay you have experienced?

☐ Less than 30 minutes

☐ 30 minutes – 1 hour

☐ 1 – 3 hours

☐ More than 3 hours

Section C: Awareness and Perceptions of UBTH's Response

1. Were you informed about the reason for the delay during downtime?

☐ Yes ☐ No

2. How would you rate the hospital's communication when downtime occurred?

☐ Very good ☐ Good ☐ Fair ☐ Poor ☐ Very poor

3. Did the hospital provide an alternative arrangement (e.g., referral to another unit/center, rescheduling, explanation)?

☐ Yes ☐ No

4. If yes, how satisfied were you with the alternative arrangement?

☐ Very satisfied ☐ Satisfied ☐ Neutral ☐ Dissatisfied ☐ Very dissatisfied

5. Overall, how do you perceive UBTH's handling of equipment downtime?

☐ Excellent ☐ Good ☐ Fair ☐ Poor ☐ Very poor

SECTION C: IMPACT ON PATIENT CARE AND SATISFACTION

Instruction: Indicate your agreement.
SA = Strongly Agree, A = Agree, N = Neutral, D = Disagree, SD = Strongly Disagree

S/N	Statement	SA	A	N	D	SD

1	I was asked to return on another day due to X-ray machine failure.					
2	The delay made me anxious or worried.					
3	The delay affected how fast I got treated.					
4	I felt dissatisfied with the delay in imaging service.					
5	I trust that the hospital is trying its best despite equipment challenges.					
6	I am satisfied overall with the services I received at UBTH.					

APPENDIX II

HEALTH RESEARCH ETHICS COMMITTEE (HREC)

UNIVERSITY OF BENIN TEACHING HOSPITAL

P.M.B. 1111 BENIN CITY NIGERIA Telephone: 052-600418 Website: ubth.org

CHIEF MEDICAL DIRECTOR
Prof. Darlington E. Obaseki
E-mail: darlobaseki@gmail.com

DIRECTOR OF ADMINISTRATION
Jim Uwadie, Esq

CHAIRMAN
Prof. (Mrs.) Antoinette N. Ofili

HREC OFFICE:
Committee email: ubthresearchethics@gmail.com
Registration Number:
NHREC-UBTH-HREC/24/12/2022B

PROTOCOL NUMBER: ADM/E 22/A/VOL.VII/2025/239

PROPOSAL TITLE: "X-RAY EQUIPMENT DOWNTIME ON PATIENTS' SATISFACTION IN A TERTIARY HOSPITAL IN BENIN CITY"

PRINCIPAL INVESTIGATOR(S): ABUABDUL MALIK

DEPARTMENT/INSTITUTION: DEPARTMENT OF RADIOGRAPHY, SCHOOL OF BASIC MEDICAL SCIENCES UNIVERSITY OF BENIN, BENIN CITY, EDO STATE

DATE CONSIDERED: SEPTEMBER 30TH, 2025

DECISION OF THE COMMITTEE: APPROVED

THIS APPROVAL DATES 30/9/2025 TO 29/9/2026. IF THERE IS DELAY IN STARTING THE RESEARCH, PLEASE INFORM THE HREC SO THAT THE DATES OF APPROVAL CAN BE ADJUSTED ACCORDINGLY

REMARK:

CHAIRMAN: PROF. (MRS) A.N. OFILI **SIGNATURE & DATE** 30/9/2025

UNIVERSITY OF BENIN TEACHING HOSPITAL RESEARCH COMMITTEE
Sign
Date
BENIN CITY P.M.B. 1111

SUPERVISOR (S): MRS. F.O. IGBINEDION

DECLARATION BY INVESTIGATOR(S):

PROTOCOL NUMBER (please quote in all enquiries)

Note that no participant accrual or activity related to this research may be conducted outside of these dates. All informed consent forms used in this study must carry the HREC assigned number and duration of HREC approval of the study. In multiyear research, endeavor to submit your annual re-port to the HREC early in order to obtain renewal of your approval and avoid disruption of your research. No changes are permitted in the research without prior approval by the HREC except in circumstances outlined in the Code. The HREC reserves the right to conduct compliance visit your research site without previous notification

Signature & Date 30th-09-2025

ubthresearchethics@gmail.com Registration Number: NHREC/24/01/2