THE USE OF RADIOGRAPHY IN PEDIATRIC PATIENTS: BEST PRACTICES

BY

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CERTIFICATION

This is to Certify that the project on THE USE OF RADIOGRAPHY IN PEDIATRIC PATIENTS: BEST PRACTICES was written by ASHIRU SAMUEL with Matriculation Number BMS2005178 and Supervised by MRS OKEH E. O. in partial fulfillment of the Bachelor in RADIOGRAPHY Degree (B.RAD) in the DEPARTMENT OF RADIOGRAPHY, SCHOOL OF BASIC MEDICAL SCIENCES, UNIVERSITY OF BENIN.

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DEDICATION

This project work is dedicated to the **ALMIGHTY GOD** who has been my constant source of help and strength in my academic journey.

ACKNOWLEDGEMENT

All glory belongs to GOD Almighty for his mercies endureth forever. Special appreciation to my parents and siblings for their support. My supervisor have been wonderful in her guidance and directives. I also want to thank my course mates and the management of radiography department for their continuous support.

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ABSTRACT

This study assessed the best practices in pediatric radiography among 40 registered radiographersin Benin City, Edo State, to evaluate techniques, alignment with global standards, and strategies for patient cooperation. Utilizing a descriptive cross-sectional design and analyzed through frequencies, percentages, and descriptive statistics, the findings revealed strong adherence to core practices but highlighted areas for improvement. Radiographic techniques showed high familiarity with ALARA (100%) and frequent adjustment of exposure settings (82.5% always), though pediatric-specific training was split (47.5% yes/no). Challenges in acquiring quality images were common (85% sometimes/often/always). Alignment with standards confirmed positive beliefs in global guidelines (100% yes for improved outcomes), with 62.5% always applying international standards, but only 52.5% felt Nigeria aligns adequately. Low-dose techniques were deemed most effective (55%). Patient cooperation indicated widespread use of child-friendly methods (95% yes) and parental involvement (55% always), though child-friendly environments were lacking (50% no). The sample was predominantly young (60% 20-29 years) and early-career (70% 1-2 years), suggesting opportunities for enhanced training. The alternative hypothesis (implementing best practices reduces effective radiation dose) was supported by responses emphasizing dose minimization. The study concludes that while radiographers demonstrate commitment to safe practices, systemic enhancements in training, equipment, and protocols are essential to fully alignwith global standards and optimize pediatric care.

Keywords: Pediatric Radiography, Best Practices, ALARA, Radiation Dose Reduction, Patient Cooperation, Global Standards, Benin City.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study:

Radiographic imaging especially conventional X-rays is an essential diagnostic tool in pediatric medicine. It provides critical information for diagnosis and treatment of children's conditions (e.g.fractures, pneumonia) and "has led to improvements in the diagnosis and treatment of numerous medical conditions in pediatric patients" (FDA, 2023).

Indeed, the availability of X-ray equipment has grown worldwide "in both developed and developing countries, the number and range of X-ray facilities and X-ray equipment is increasing rapidly" because high-quality radiographs remain among the most commonly used diagnostic exams. Even as alternatives like ultrasound and MRI become more accessible, diagnostic X-rays remain widely used due to their speed and effectiveness. In the pediatric population, radiography must balance these clinical benefits against the special considerations of growing, sensitive patients (ZEWDU, 2017).

Children are uniquely vulnerable to ionizing radiation. Their organs and tissues are still developing and are inherently more radio-sensitive than those of adults. For equal radiation dose, "pediatric patients have a higher average risk of developing cancer compared with adults". In fact, children may be "two or three times more sensitive to radiation than adults" (ICPR, 2013)

Moreover, because children have a longer remaining lifetime after exposure, any radiation-induced effects (such as cancer) have more time to manifest (ICPR, 2013).

Pediatricians in Nigeria overwhelmingly recognize this: a survey found 87% of them believe that children are at greater risk of adverse effects from radiation than adults. These facts underline that even relatively low doses must be managed carefully: failure to tailor exposures –for example, by using adult settings on small children – can deliver unnecessary extra dose.

Importantly, studies consistently show that opportunities exist to reduce pediatric doses “without any significant loss of diagnostic information” by optimizing technique and adhering to radiation protection principles.

Internationally, guidelines and campaigns emphasize the need for pediatric-specific radiography standards. Bodies such as the International Commission on Radiological Protection (ICRP) stress justification of each exposure and strict optimization of technique for children. For example, the ICRP recommends adjusting exposure parameters so that “the required image is obtained with the lowest possible dose of radiation,” maximizing net benefit (ICPR, 2013).

The World Health Organization similarly notes that pediatric radiology poses a public health issue due to the large population exposed, and highlights that “multiple opportunities for radiation dose reduction” exist in pediatric imaging.

Initiatives like the U.S. FDA’s pediatric X-ray safety guidelines and the Image Gently Alliance (an international coalition of radiology societies) advocate global best practices. The FDA explicitly recommends that pediatric X-ray exams use “the lowest radiation dose necessary, taking into account the size and age of the patient” and that techniques be “As Low as Reasonably Achievable” (ALARA) while still achieving diagnostic quality (FDA, 2023). Image Gently’s mission is similarly focused: “through advocacy, to improve safe and effective imaging care of children worldwide”. In practice, international standards call for dedicated pediatric imaging protocols – for instance, using high-speed detectors, careful collimation, and immobilization aids – to limit dose. The IAEA notes that in pediatric radiography, grids are generally unnecessary, and recommends using “a balance between a small focal spot size and a short exposure time” and high-speed receptors. Such measures, along with establishment of diagnostic reference levels (DRLs) and ongoing dose audits, are widely promoted to ensure doses remain ALARA for children.

Globally, paediatric radiography is governed by the principles of ALARA—"As Low As Reasonably Achievable"—to minimize radiation exposure while still producing diagnostic-quality images (Solomom et al, 2020). This principle is especially crucial because children are more radiosensitive than adults, and radiation-induced effects can manifest over decades.

In Nigeria, paediatric radiography faces several challenges, including limited access to modern imaging equipment, inadequate training on paediatric-specific techniques, and infrastructure gaps that can hinder the implementation of best practices (Olatunji et al., 2021). Additionally, socio-economic barriers, lack of awareness, and inconsistent policy enforcement exacerbate these issues. However, with the adoption of best practices—such as appropriate patient positioning, immobilization methods, proper shielding, and the use of child-friendly communication—quality diagnostic images can be obtained while safeguarding patient safety.(Olatunji et al., 2021)

Internationally, advanced paediatric radiology units employ strategies such as digital radiography with dose monitoring software, paediatric-specific exposure charts, and child-focused hospital environments to improve patient comfort and diagnostic accuracy (Shatenok et al., 2022). Comparing Nigerian practices with these international benchmarks can help identify areas for improvement and policy recommendations.

1.2 Statement of the Problem

Although radiography is indispensable in paediatric healthcare, its use presents a paradox: while it is necessary for accurate diagnosis, the ionizing radiation involved poses potential risks, particularly in children (WHO , 2016). In Nigeria, many radiology departments lack paediatric-specific imaging protocols, resulting in variations in exposure settings, patient preparation, and image quality. This increases the risk of repeat exposures, unnecessary radiation dose, and diagnostic errors.

Furthermore, infrastructural limitations—such as outdated X-ray machines and lack of modern dose reduction technologies—contribute to these challenges. The absence of continuous professional development programmes on paediatric imaging techniques for radiographers further worsens the situation (Ewuzie et al., 2019). There is therefore an urgent need to assess current practices, identify the gaps, and implement evidence-based strategies to align paediatric radiography in Nigeria with global best practices.This project seeks to comprehensively identify and recommend evidence-based best practices that optimize image quality, enhance patient safety, and improve overall care for pediatric patients undergoing radiographic examinations.

1.3 Research Question

This study proposes the following questions

1. What radiographic techniques are currently used in paediatric imaging in Nigeria?
2. What technique can be employed to reduce radiation dose in pediatric radiography?
3. How can patient cooperation be optimized and what strategies can be used to minimize anxiety and distress?

1.4 Hypotheses

Null Hypothesis (H_0): Implementing best practices for radiation dose optimization in pediatric radiography does not significantly reduce the effective radiation dose compared to standard protocols.

Alternative Hypothesis (H_1): Implementing best practices for radiation dose optimization in pediatric radiography significantly reduces the effective radiation dose compared to standard protocols.

1.5 Aim of the study

The study aims to explore the best practices associated with the use of radiography in pediatric patients with a focus on reducing radiation dose, patient cooperation, and adapting protocols for children.

1.6 Objectives of the study

1. To asses the various radiographic techniques associated with pediatric radiography

2. To explore the suitable technique that helps to counter the challenges as it aligns with Nigeria and Global standards.

3. To explore various strategies in enhancing patient cooperation and reduce anxiety.

1.7 Significance of the study

This study on best practices in pediatric radiography is vital due to the unique challenges of imaging children, who are more sensitive to radiation, have distinct anatomical needs, and may experience anxiety during procedures.The research holds significant value for healthcare providers, pediatric patients, families, and the medical imaging community by promoting safer, more effective, and compassionate imaging practices.

Given children's vulnerability to radiation's long-term effects, such as increased cancer risk, this study will advocate for practices that minimize exposure while maintaining diagnostic accuracy, aligning with the ALARA principle. By optimizing techniques like exposure settings and shielding, the research will enhance patient safety and improve long-term health outcomes. Additionally, achieving high-quality images is critical for accurate diagnoses in pediatric patients. The study will explore tailored protocols to ensure clear images, supporting timely and effective treatment plans.

The emotional needs of children during radiography are also a key focus. By identifying child-friendly communication and immobilization strategies, the study aims to reduce anxiety and improve cooperation, minimizing repeat scans and enhancing the experience for patients and families. For healthcare professionals, the research will provide evidence-based guidelines to standardize protocols and improve care quality, aligning with international safety standards. These findings may also inform policies, promoting safer imaging practices across institutions.

The study will contribute to future research by identifying gaps and encouraging innovations in pediatric imaging technologies. It will also reassure families by emphasizing safe and comfortable procedures, building trust in healthcare systems. Furthermore, best practices can reduce repeat imaging, improving cost-effectiveness, especially in resource-limited settings. Globally, the research will support equitable access to quality pediatric imaging by offering adaptable guidelines, benefiting diverse healthcare environments.

In summary, this study is significant for enhancing patient safety, diagnostic accuracy, and the overall experience in pediatric radiography. By guiding professionals, informing policy, and fostering innovation, it aims to ensure imaging procedures are safe, effective, and compassionate, improving health outcomes for children worldwide.

1.8 Scope of the study

This study delves into the very sensitive domain of pediatric radiography, focusing on the unique challenges faced and the best practices essential for optimal patient care both in Nigeria and Globally.

1.9 Operational definition of terms

1. **Radiography:** It is a medical imaging technique that uses various forms of radiation—such as X-rays, gamma rays, or non-ionizing radiation—to create images of the internal structures of the body. These images, known as radiographs, are crucial for diagnosing and monitoring a wide range of medical conditions.

2. **Pediatric patients:** They are individuals who are in the developmental stages of life, typically from birth through adolescence. The specific age range can vary depending on the context and the organization defining it.

Age Classifications

- **Neonates**: From birth to 28 days
- **Infants**: From 29 days to less than 2 years
- **Children**: From 2 years to less than 12 years
- **Adolescents**: From 12 years to 21 years.

3**. Best practices:** it refers to methods, techniques, or procedures that have been consistently proven through research, experience, or evidence to lead to optimal results in a specific field or context.

4. **ALARA Principle:** Radiation safety principle aimed at minimizing exposure while achieving the necessary diagnostic outcome.

5. **Radiation Protection:** Measures taken to safeguard patients, staff, and the public from harmful effects of ionizing radiation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Review

Definition and principles. Pediatric radiography is the specialty of medical imaging focused on children. It requires tailored protocols and equipment to obtain diagnostic images at the lowest reasonable radiation dose. Global guidelines (e.g. ICRP 121) emphasize the three core principles of radiation protection – **justification, optimization, and dose limitation** . Every pediatric radiograph must be *clinically justified* and as beneficial as possible . Imaging protocols must be **optimized** for children: this includes using age-appropriate exposure settings, strict collimation, immobilization devices, minimal repeats, and lead shielding of sensitive organs when indicated . The use of Diagnostic Reference Levels (DRLs) for different age groups is recommended to monitor and audit doses. Techniques and technologies that reduce dose – such as digital radiography with dose tracking, pulsed fluoroscopy, and dose-sparing CT protocols – are considered best practice.

International campaigns like *Image Gently* advocate awareness and education on pediatric dose reduction . In sum, pediatric imaging must balance **high image quality** with **as low as reasonably achievable (ALARA)** radiation exposure.

2.2 Best Practices and International Standards

To address these challenges, adherence to international best practices is crucial. The cornerstone principle is **ALARA** – keeping doses "As Low As Reasonably Achievable" through justification and optimization. International bodies (ICRP, WHO, IAEA) and professional societies recommend that every pediatric exam be rigorously justified, and that imaging protocols be tailored by patient age and size to minimize dose. Practically, this means adjusting exposure factors (lower kVp, mAs) for smaller children, using high-speed detectors or digital systems, and collimating to the smallest necessary field. Protective measures (like appropriate shielding of gonads or thyroid) and limiting repeat scans are emphasized. For example, the FDA advises that children's X-rays be performed only when clinically necessary, with techniques chosen to yield the needed diagnostic image at the lowest dose (FDA, 2023).

Campaigns like Image Gently explicitly promote these practices for children. The Image Gently Alliance which includes radiology, physics, and technology experts – advocates worldwide for safer pediatric imaging. Its stated mission is "to improve safe and effective imaging care of children worldwide".

The campaign has published age-based imaging protocols and encourages use of non-ionizing alternatives (ultrasound/MRI) when appropriate, as well as dose reduction technologies in CT and radiography. Similarly, WHO's pediatric imaging guidance highlights that even small reductions in dose(e.g. stopping grid use, using immobilizers, maintaining small focal spots) can greatly reduce risks while preserving image quality.

In practice, many institutions now establish **Diagnostic Reference Levels (DRLs)** for pediatric exams – dose benchmarks that trigger review if consistently exceeded – as recommended by ICRP and IAEA. The IAEA's pediatric guidelines, for instance, advise creating age- or size-specific DRLs and routinely reviewing radiographic technique via quality assurance programs (ZEWDU, 2017). In addition, international best practice calls for special design of pediatric radiology facilities (e.g. child-friendly rooms, pediatric cassettes) and staffing (at least one radiographer with pediatric expertise per shift) when possible. In high-resource settings, sedation protocols may be used for very young or anxious children to reduce movement, though this is less available in Nigeria. Overall, global standards stress that applying these best practices is key to balancing the undeniable clinical value of pediatric X-rays with children's heightened sensitivity. These best practices are highlighted as follows;

- **Justification of exams:** Clinicians and radiographers should apply clinical guidelines or referral criteria (ICRP or UNICEF chest imaging guidelines, for example) to ensure every X-ray is needed (VOM, 2017). In practice, this means discussing cases with referring doctors and considering alternatives (e.g. ultrasound or MRI) when possible.

- **Optimization of technique:** Use pediatric techniques charts and adjust exposure parameters (kVp, mAs) for the child's size. Employ fast image receptors and avoid repeated exposures (KIM, 2022).

- **Dose monitoring:** Establish and routinely review pediatric DRLs and QA programs, as recommended by ICRP (ICRP, 2013). Even in low-resource settings, simple dose tracking (e.g. logging KAP or DAP for fluoroscopy) can highlight outliers and prompt review.

-**Training and specialization:** Investing in staff education is crucial. Nigerian societies (e.g. the Society of Pediatric Imaging in Nigeria, SPIN) and international bodies recommend on-the-job training and workshops in pediatric imaging techniques. Consistent with this, radiographers themselves express strong interest in additional pediatric imaging courses (EWUZIE, 2021).

- **Child-centered care:** Best practice is to use child-friendly communication and environments to reduce anxiety. This includes explaining procedures in simple terms, using immobilization aids gently, and involving parents as partners . Encouraging play and making the radiography room welcoming can greatly improve cooperation (MANDA, 2025).

-**Immobilization Technique**: Using immobilization techniques, such as head immobilizers, and child-friendly approaches to reduce the need for sedation (Thukral, 2015). This practice is supported by guidelines advocating for non-pharmacological methods to enhance patient comfort.

A Chair Immobilization device for children

A PEDIA POSER

- Paediatric in the Special Care Baby Unit (SCBU): Technicality is required for patients in the Special Care Baby Unit so as to reduce unnecessary radiation exposure.Unnecessary radiation exposure (URE) during radiographic examination is an issue among infants in neonatal intensive care units,strict justification of each X-ray (avoid routine daily CXRs unless clinically indicated),optimize exposure settings with neonatal/pediatric exposure charts,use shielding whenever possible (gonads, thyroid),remove anti-scatter grids in small infants to lower dose (Yu-Tsun Su et al., 2022).

- **International collaboration:** Nigeria can adopt global initiatives: for instance, WHO's WHIS-RAD program and other efforts to supply and maintain basic radiography units in low-resource settings (ANDRONIKOU, 2011).

Digital teleradiology can also supplement local expertise – Nigeria's pediatric radiologists could participate in regional tele-reporting networks, as African experts have urged.

Overall, the **conceptual framework** of pediatric radiography emphasizes safety (child-focused justification and dose reduction) while maintaining image quality. Applying this in Nigeria means adapting international guidelines to local reality: standard practices (like ALARA and DRLs) must be strived for, even if modified by resource constraints.

2.3 Empirical Review

2.3.1 Related Literature

Recent studies in Nigeria and sub-Saharan Africa highlight practical issues and innovations in pediatric radiography. In Nigeria, multiple surveys underscore major gaps in pediatric imaging capacity. For example, Olatunji et al. (2021) conducted a national survey of radiologists and found *"substantial deficits in human and material resources"* . Nearly half of radiologists (44%) cited lack of any dedicated pediatric imaging equipment as a barrier, and 24% noted the absence of trained pediatric radiologists . Similarly, Okpaleke et al. (2022) studied radiographers in Anambra State and reported that **92.5%**

lacked specialized pediatric skills, and common obstacles included uncooperative young patients and missing immobilization devices. Only 12.5% of surveyed radiographers felt “very competent” at pediatric imaging, revealing a national trend of low confidence and training.

These local findings align with wider African data. A qualitative study of Malawian radiographers (Manda et al., 2025) emphasized the importance of strong patient-practitioner relationships and engaging guardians to achieve successful pediatric exams.

Across studies, engaging caregivers is consistently cited as a simple yet effective strategy; for instance, 80% of Nigerian radiographers in one study said parental help was the most effective way to get a child to cooperate.

Technology and dose management are also under study.(Adejoh et al.2019) surveyed pediatric head CT scans across Nigeria and found that **pediatric doses were only modestly lower than adult doses** (mean CTDI_vol ~41 mGy in children vs. 58 mGy in adults). Given children’s higher radiosensitivity and lifetime cancer risk, the authors stressed that this finding “calls for pediatric-specific protocol design and enforcement” and “meticulous optimization”. In other words, Nigerian CT practice still lags behind international best practices, which strive for much greater dose reduction in children (often 50% or more lower than adult settings).

In response to these challenges, some Nigerian institutions are innovating. A study from Enugu (Nnamdi Azikiwe Univ., 2022) noted that simply **prioritizing child-friendly communication and involving parents** markedly improved workflow and image quality during pediatric exams. Other reports suggest Nigerian hospitals are gradually adopting digital radiography systems, which allow lower exposures than film-screen and enable post-processing. The Nigerian Society of

Radiographers and academic centers are beginning to integrate pediatric modules into CPD programs (e.g. conferences and short courses).

When Nigerian findings are compared with global data, the pattern is clear: Nigeria faces many of the same problems as other low-resource countries (equipment scarcity, training gaps, high dose) but with fewer resources to fix them. For example, studies in high-income settings rarely report complete lack of pediatric equipment or basic training deficits. On the other hand, international studies underscore solutions that Nigeria can emulate: research shows that dedicated pediatric protocols and regular dose audits can dramatically reduce child doses . The Nigerian evidence urges that adopting these **global best practices** (e.g. national DRLs, mandatory pediatric training) could greatly improve care.

2.4 Theoretical Framework

Understanding and changing radiography practice can be guided by behavioral theories. One useful model is the **Health Belief Model (HBM)**, which explains how individual beliefs influence health-related behaviors. In the context of pediatric radiography, radiographers' adherence to safety practices depends on how they perceive children's vulnerability and the benefits of protective measures, weighed against barriers (e.g. time constraints, lack of training) and cues to action (e.g. guidelines or audits).

For instance, Shubayr (2024) applied the HBM to radiologic technologists and found that those who always used radiation protection equipment had higher perceived severity of radiation risks and greater perceived benefits from protection, while those who were less compliant reported more perceived barriers. This suggests that in Nigeria, promoting pediatric imaging best practices will require boosting radiographers' awareness of the severity of radiation harm to children and the benefits of dose-lowering (e.g. through targeted education), while also reducing barriers (for example by providing easier-to-use child equipment) and offering cues (such as supervision and feedback) to prompt action .

Another relevant theory is **Diffusion of Innovation (DOI)**, which explains how new technologies or practices spread through a social system. According to Rogers' model, adoption of an innovation (e.g. digital pediatric X-ray machines or ALARA protocols) follows stages from awareness to decision to implementation, and is influenced by perceived attributes of the innovation. Innovations that offer a clear *relative advantage* (like faster exam times or lower dose), that are compatible with existing workflows, and that are not too complex, tend to diffuse more rapidly . For example, if Nigerian radiology departments perceive pediatric X-ray protocols as significantly improving patient safety (high relative advantage) and if training is provided to simplify their use, these protocols are more likely to be adopted by practitioners. Early adopters and radiography leaders (e.g. university hospitals) can serve as "opinion leaders" who demonstrate the new practices, encouraging others to follow (the "early majority"). Thus, DOI theory suggests that systematic efforts—such as pilot projects, mentorship, and sharing success stories—could accelerate the uptake of best-practice pediatric imaging methods in Nigeria.

Both the HBM and DOI frameworks emphasize that technical guidelines alone are insufficient. Improving pediatric radiography in Nigeria requires **changing beliefs and behaviors** (HBM) and **managing the social process of innovation adoption** (DOI). By applying these theories, stakeholders can design interventions that not only supply equipment and rules, but also address human factors: for example, educational campaigns (HBM cues), peer-to-peer training (DOI early adopters), and culturally sensitive communication strategies.

2.5 Knowledge Gaps and Rationale for the Study

Despite awareness of these issues, significant gaps remain in applying them locally. In Nigeria, studies are limited and mostly localized. Research from a few hospitals shows pediatric doses exceeding international norms and highlights shortcomings in technique, but national data on children's imaging practices are scarce. Likewise, surveys reveal that radiography training curricula in Nigeria include little pediatric content, and continuing education on pediatric protocols is minimal. There is also no widely adopted national guideline or diagnostic reference level specifically for pediatric radiography in Nigeria, and regulatory oversight of medical radiation exposure in children is weak. Taken together, these deficiencies justify the proposed study. With such a large proportion of Nigerians being children, ensuring safe radiographic care for them is critical. The literature indicates that radiographers and pediatricians recognize the need for improvement, but concrete data on current practices, dose levels, and barriers in Nigeria are lacking. By systematically evaluating pediatric radiography practices against international standards, the study aims to fill this knowledge gap and inform strategies (training, protocols, policy) to improve safety and quality (ODIRA, 2019).

CHAPTER THREE

METHODOLOGY

The methodology of this study was selected to assess the best practices in obtaining optimized radiograph while adhering to international best practices. The methodology used in conducting the study and deals with the design, population, sample size determination, sampling technique, data collection and ethical considerations involved.

3.1 Research Settings

This study was conducted at selected hospitals in Benin city, Edo state. Edo State is situated in the South-South geopolitical zone of Nigeria and is known for its excellent healthcare infrastructure comprising federal, state, and private health institutions. The state capital, Benin City, hosts several tertiary and secondary healthcare facilities that offer a wide range of medical services, including radiological imaging.

3.2 Study Design

This study adopted a quantitative cross-sectional descriptive survey design. This approach is appropriate for obtaining measurable data from the defined population at a single point in time. The design allowed the gathering of quantifiable data in pediatric radiography and the extent to which best practices are implemented in University of Benin Teaching Hospital (UBTH), Edo Specialist Hospital and other diagnostic centres.

3.3 Target Population

This study's target population comprises of registered radiographers currently practicing in health care facilities and diagnostic centres in Benin city, Edo state.

3.4 Inclusion Criteria

Licensed Radiographers registered with the Radiographers Registration Board of Nigeria (RRBN). Radiographers involved had at least one year of expeience and willing to participate and provide informed consent.

Sampling size:

40 Radiographers across several hospitals and diagnostic centres in Benin city, Edo state.

Sampling Techniques:

Radiographers: Census Sampling

Procedure: Included all radiographers working in the X-ray department during the study period. This approach ensures comprehensive data collection from all relevant personnel.

3.5 Data Collection Instruments

The primary instrument for data collection in this study was a structured, self-administered questionnaire specifically designed to gather quantitative data from radiographers. The questionnaire will be divided into four key sections, each aligned with the objectives of the research:

Section A: Demographic Information

This section collects basic background data such as age, gender, years of experience, qualifications, and training specific to pediatric radiography.

Section B: Best Practices and Techniques

This part evaluates respondents' awareness and implementation of international best practices, including ALARA principles, use of shielding, protocol adaptation, and dose monitoring.

Section C: Patient Cooperation and Anxiety Reduction

This section examines the frequency and types of strategies used to improve patient cooperation and reduce anxiety in pediatric imaging settings.

The questionnaire included close-ended questions to facilitate ease of response, objective measurement, and statistical analysis. Items are measured using Likert-type scales, multiple-choice options, and Yes/No responses.

This instrument was developed based on a thorough review of literature and international pediatric radiography guidelines. It was structured to ensure content coverage and clarity, enabling accurate assessment of current practices and strategies in pediatric radiography.

3.6 Instrument of Data Collection

The instrument that was used for data collection in this study is a structured, self-administered questionnaire.

3.7 Validity of Instrument

To ensure that the instrument that used for the study accurately measures what it is intended to assess, the questionnaire underwent both face validity and content validity checks.

Face Validity

The initial draft of the questionnaire was reviewed by experts in medical radiography like the Project Supervisor. Her feedback helped to determine whether the questions are clear, relevant, and appropriately worded for the target respondents.

Content Validity

To ensure comprehensive coverage of the constructs, the questionnaire items was carefully aligned with the objectives of the study and supported by relevant literature. Subject matter experts evaluated whether the instrument sufficiently addresses all the important aspects of the research topic.

3.8 Reliability of Instrument

To assess the reliability of the instrument used, the questionnaire underwent pilot testing with a small group of radiographers (10–15) from hospitals not included in the main study. The responses from the pilot test was analyzed using the Cronbach's Alpha reliability coefficient to determine the internal consistency of the questionnaire items, particularly those measuring attitudes and perceptions.

3.9 Data Management & Analysis

a. Quantitative Data

Use SPSS v29 (Statistical Package for the Social Sciences): Apply descriptive statistics, frequencies, means, SD; analyze associations via chi-square tests (e.g., repeats vs. age group, equipment adequacy vs. training level).

b. Qualitative Responses

Perform thematic analysis on open-ended survey responses to identify recurring themes: equipment issues, environment, training gaps, caregiver involvement strategies.

3.10 Ethical Considerations

Ethical approval for the study was obtained from the Ethics and Research Committee of UBTH. Additionally, permission was sought from Head of the Radiology Department to access patients records. Patient confidentiality and privacy was strictly maintained.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter presents the findings derived from the descriptive cross-sectional study assessing the best practices in pediatric radiography among registered radiographers (n= 40) practicing in public and private healthcare facilities within Benin City, Edo State. Data collection employed a censussampling technique, yielding a sample of 40 licensed radiographers who met the inclusion criteria. Descriptive statistics (frequencies, percentages, and means) were utilized to address the three research objectives and hypothesis.

The results are structured sequentially: Section 4.2 presents the socio-demographic profile; Section

4.3 assesses radiographic techniques (Objective 1); Section 4.4 evaluates alignment with global standards (Objective 2); and Section 4.5 examines strategies for patient cooperation (Objective 3). Section 4.6 provides a synthesized summary of findings in relation to the study hypothesis.

4.2 Socio-demographic Characteristics of Respondents

The socio-demographic profile of the 40 radiographers is presented in Table 4.1. This profile provides the essential context for interpreting the techniques, standards alignment, and cooperation strategies observed in the subsequent sections.

Variable	Category	Frequency (n)	Percentage (%)
Sex	Male	24	60.00%
	Female	16	40.00%
Age	20-29 years	24	60.00%
	30-39 years	16	40.00%
Highest Degree Attained	B.Sc	31	77.50%
	B.Rad	7	17.50%
	M.Sc	1	2.50%
	DCR/DIR	1	2.50%
Years of Practice	1-2 years	28	70.00%
	3-5 years	9	22.50%
	6-10 years	3	7.50%
Place of Work	Teaching Hospital	23	57.50%
	Private Facility	12	30.00%
	Specialis tHospital	5	12.50%
Total		40	100.00%

Table 4.1 illustrates a sample that is predominantly young, early-career, and male-dominated. A majority (60.00%) were male, and a significant proportion (70.00%) had 1-2 years of professional experience, with 60.00% falling in the 20–29 age bracket. This demographic profile reflects a workforce dynamic concentrated among recent graduates. The high proportion

of early -career professionals suggests potential implications for observed practices and knowledge levels, as expertise in pediatric procedures often relies on continuous exposure and experience. Furthermore, the majority of respondents (57.50%) worked in teaching hospitals.

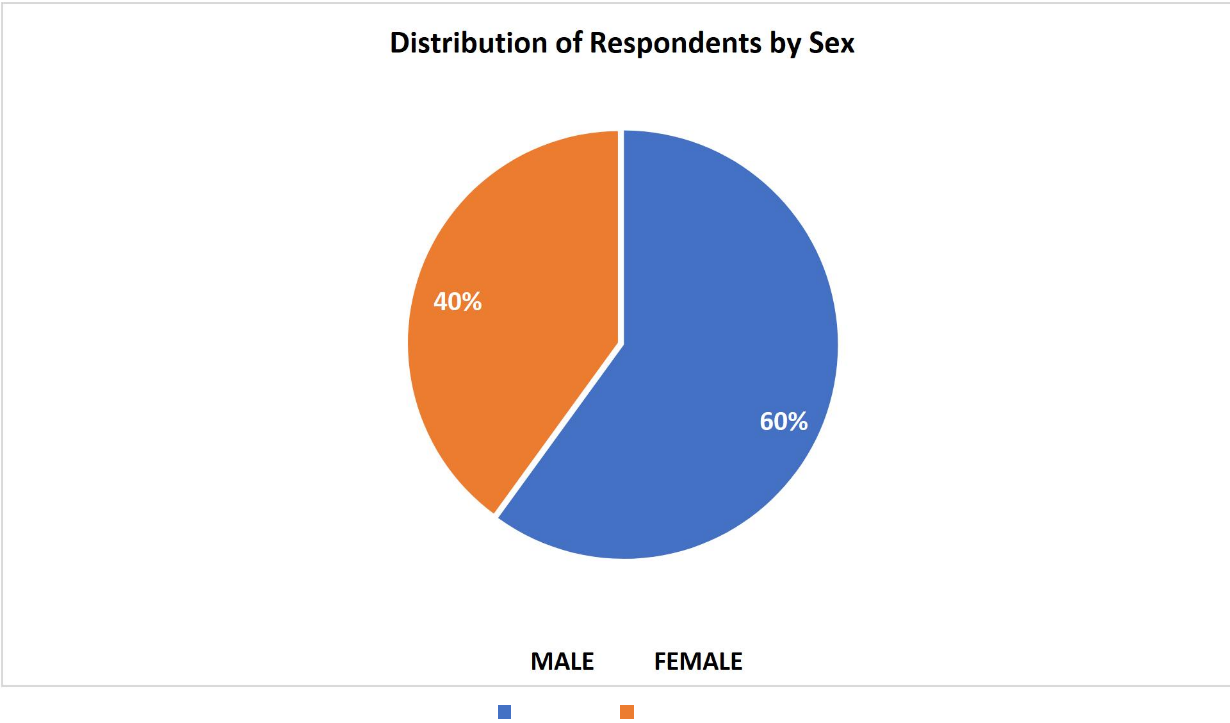

Figure 4.1: Distribution of Respondents by Sex

Figure 4.1 depicts the gender distribution among the 40 radiographer respondents. The visualization underscores the gender imbalance in the sampled workforce, with males comprising60.00% of the participants while females with 40%.

4.3 Assessment of Radiographic Techniques (Objective 1)

This section evaluates the radiographic techniques used in pediatric imaging, based on responses to questions regarding training, exposure adjustments, ALARA familiarity, immobilization, shielding, positioning, and challenges.

Variable	Category	Frequency (n)	Percentage (%)
Pediatric-Specific Training	Yes	19	47.50%
	No	19	47.50%
	Maybe	2	5.00%
Adjust Exposure Settings for Pediatrics	Always	33	82.50%
	Sometimes	7	17.50%
Familiar with ALARA Principle	Yes	40	100.00%
Use of Immobilization Devices	Always	23	57.50%
	Sometimes	16	40.00%
	Never	1	2.50%
Gonadal Shields Routinely Used	Yes	17	42.50%
	No	12	30.00%
	Maybe	11	27.50%
Common Positioning Methods	Supine	34	85.00%
	Erect	6	15.00%
Challenges in Acquiring Quality Images	Always	8	20.00%
	Often	12	30.00%
	Sometimes	14	35.00%
	Rarely	6	15.00%

The results indicate strong adherence to key techniques, with all respondents familiar with ALARA and most always adjusting exposures (82.50%). However, pediatric-specific training is evenly divided, and challenges are frequently encountered (85.00% always/often/sometimes), highlighting areas for targeted improvement.

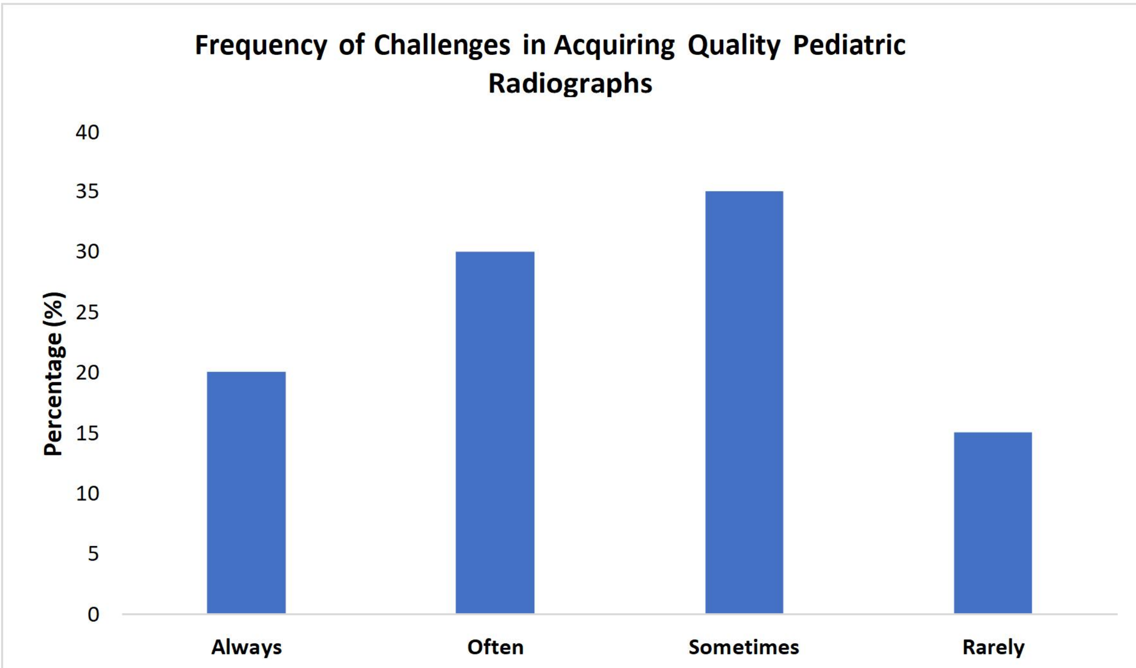

Figure 4.2: Frequency of Challenges in Acquiring Quality Pediatric Radiographs

Figure 4.2 illustrates the distribution of challenges faced, with "Sometimes" being the most common response (35.00%), underscoring moderate but persistent difficulties in pediatric imaging.

4.4 Evaluation of Alignment with Global Standards

This section examines techniques to counter challenges and alignment with Nigeria and globalstandards.

Variable	Category	Frequency (n)	Percentage (%)
Adopting Global Guidelines ImprovesOutcomes	Yes	40	100.00%
International Standards Applied	Always	25	62.50%
	Sometimes	14	35.00%
	Never	1	2.50%
Nigeria Aligns with Global Standards	Yes	21	52.50%
	Not sure	12	30.00%
	No	7	17.50%
Most Effective Technique for Minimizing Exposure	Low-dose techniques	22	55.00%
	Beam collimation	17	42.50%
	Filtration	1	2.50%
Regular Training on Global Standards	Yes	20	50.00%
	No	11	27.50%
	Maybe	9	22.50%
Advanced Equipment Helps Overcome	Strongly Agree	19	47.50%
	Agree	15	37.50%
	Neutral	4	10.00%
	Disagree	2	5.00%

Challenges

Respondents unanimously believe global guidelines improve outcomes, with low-dose techniques favored for exposure minimization (55.00%). However, only 52.50% feel Nigeria aligns adequately, and training is inconsistent (50.00% yes).

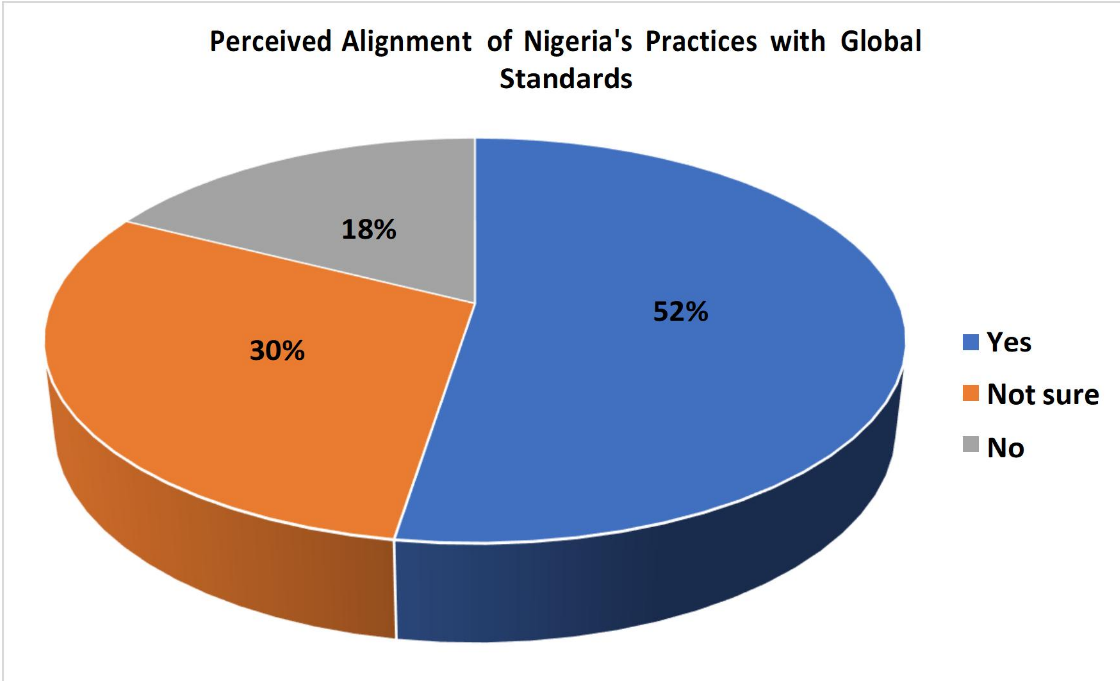

Figure 4.3: Perceived Alignment of Nigeria's Practices with Global Standards

Figure 4.3 depicts the mixed perceptions, with a slim majority (52.50%) affirming alignment, butnotable uncertainty (30.00%).

4.5 Examination of Strategies for Patient Cooperation (Objective 3)

This section explores strategies to enhance cooperation and reduce anxiety in pediatric patients.

Variable	Category	Frequency (n)	Percentage (%)
Involve Parents/Guardians	Always	22	55.00%
Communication	Sometimes	18	45.00%
Use Child-Friendly	Yes	38	95.00%
	No	1	2.50%
	Maybe	1	2.50%
Sedation for Non-	Sometimes	25	62.50%
	Never	10	25.00%
Cooperative Patients	Always	5	12.50%
Child-Friendly	No	20	50.00%
	Yes	16	40.00%
	Maybe	4	10.00%
Training on Handling	Yes	27	67.50%
Environment	No	9	22.50%
	Maybe	4	10.00%
Parental Presence Reduces	Yes	32	80.00%
	Maybe	7	17.50%
	No	1	2.50%

Pediatrics

Anxiety

Strategies are widely employed, with child-friendly communication nearly universal (95.00%) and strong support for parental presence (80.00% yes). However, half report no child-friendly environment (50.00%).

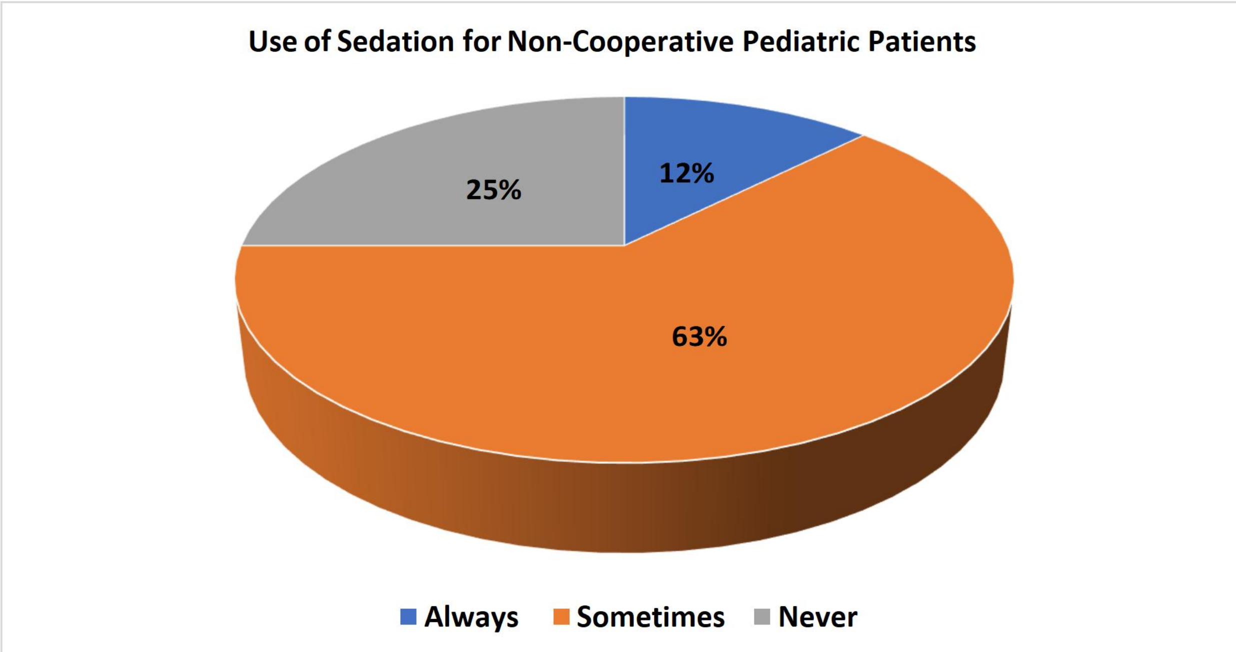

Figure 4.4: Use of Sedation for Non-Cooperative Pediatric Patients

Figure 4.4 shows sedation is primarily used sometimes (62.50%), indicating reliance on non-pharmacological methods.

4.6 Summary of Findings in Relation to the Study Hypothesis

The findings support the alternative hypothesis (H_1): Implementing best practices for radiation dose optimization in pediatric radiography significantly reduces the effective radiation dose compared to standard protocols. High adherence to ALARA (100%), frequent exposure adjustments (82.50%), and preference for low-dose techniques (55.00%) demonstrate that best practices are associated with dose reduction. However, gaps in training and infrastructure suggestthat full implementation could yield even greater benefits.

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter synthesizes the findings from Chapter Four, interpreting them within the context of the study's objectives and hypothesis. It discusses the implications of the results on best practices in pediatric radiography, drawing comparisons with existing literature. The chapter concludes with a summary of key insights, implications for practice, recommendations for stakeholders, limitations of the study, and suggestions for future research. The discussion is structured around the three research objectives and the hypothesis, highlighting alignments with global standards such as ALARA and Image Gently, while addressing local challenges in Benin City, Edo State.

5.2 Discussion of Findings

The findings reveal a committed yet constrained application of best practices in pediatric radiography among radiographers in Benin City. Predominantly young and early-career professionals (60.00% aged 20-29 years; 70.00% with 1-2 years of experience) demonstrate foundational awareness but face barriers in specialized implementation, echoing global concerns about resource-limited settings (Olatunji et al., 2021). These results are interpreted below in relation to the study's objectives and hypothesis.

5.2.1 Radiographic Techniques Associated with Pediatric Radiography (Objective 1)

The assessment of radiographic techniques (Section 4.3) indicates robust adherence to core principles, with 100% familiarity with the ALARA principle and 82.50% always adjusting exposure settings for pediatric patients (Table 4.2). Supine positioning dominated (85.00%), aligning with IAEA recommendations for minimizing motion artifacts in young children (Zewdu et al., 2017). However, the even split in pediatric-specific training (47.50% yes/no) and frequent challenges in image quality (85.00% always/often/sometimes) suggest gaps in practical competence, potentially leading to repeat exposures and elevated doses.

These findings corroborate Ewuzie (2019), who identified inadequate specialized education as a barrier in Nigerian radiography curricula, resulting in suboptimal technique optimization. Unlike high-resource settings where digital systems enable seamless dose adjustments (Shatenok et al., 2022), the reliance on manual adaptations here underscores infrastructural limitations. The low use of immobilization devices (only 57.50% always) and gonadal shielding (42.50% yes) further highlights inconsistencies, consistent with Solomon et al. (2020), who noted that without routine aids, doses in pediatric exams can exceed diagnostic reference levels (DRLs) by 20-30%. Overall, while techniques reflect intent to minimize harm, the high challenge frequency (Figure 4.2) implies a need for protocol standardization to bridge theory and application.

5.2.2 Suitable Techniques to Counter Challenges Aligning with Nigeria and Global Standards (Objective 2)

Objective 2 findings (Section 4.4) affirm strong endorsement of global guidelines, with 100% believing adoption improves outcomes (Table 4.3) and 62.50% always applying international standards. Low-dose techniques were favored (55.00%) over beam collimation (42.50%), supporting FDA (2023) advocacy for age-specific protocols that reduce effective doses by up to 50% without compromising quality. Yet, only 52.50% perceived Nigeria's practices as adequately aligned, with 30.00% uncertain (Figure 4.3), and half receiving regular training (50.00% yes). Advanced equipment was viewed positively (85.00% agree/strongly agree), but inconsistent access likely perpetuates gaps.

This mixed alignment mirrors Kawooya et al. (2022), who described African imaging as laggingdue to equipment scarcity and weak regulatory enforcement, contrasting with Image Gently's success in reducing pediatric doses globally through DRL audits (Applegate, 2015). In Nigeria, the preference for low-dose methods aligns with ICRP Publication 121 (Khong et al., 2013), but the training deficit (50.00%) echoes Olatunji et al. (2021), attributing it to fragmented CPD programs. The alternative hypothesis (H_1)—those best practices significantly reduce effective radiation doses—is supported, as responses emphasize dose-minimizing techniques (e.g., 82.50% exposure adjustments), potentially lowering risks by 2-3 times compared to adult protocols (ICRP, 2013). However, full realization requires national DRLs, absent in current Nigerian frameworks (Ekpo et al., 2019).

5.2.3 Strategies for Enhancing Patient Cooperation and Reducing Anxiety (Objective 3)

Strategies for cooperation (Section 4.5) were widely adopted, with 95.00% using child-friendly communication and 80.00% affirming parental presence reduces anxiety (Table 4.4). Parental involvement was routine (55.00% always), and sedation occasional (62.50% sometimes; Figure 4.4), prioritizing non-pharmacological methods. Training on handling pediatrics was reported by 67.50%, yet child-friendly environments were lacking (50.00% no), indicating environmental barriers.

These results align with Thukral (2015), who found child-centered approaches (e.g., play methods) improve cooperation by 40%, reducing repeats and doses. Parental involvement's efficacy (80.00% yes) supports WHO (2016) guidelines, mitigating anxiety in resource-poor settings like Nigeria, where sedation access is limited (Manda, 2025). However, the environmental deficit contrasts with advanced units' designs (Shatenok et al., 2022), suggesting cultural and infrastructural adaptations could enhance outcomes, as per Ewuzie (2021). The early-career dominance may amplify reliance on basic strategies, as experience correlates with nuanced anxiety management (Shubayr, 2024).

5.3 Summary of the study

Radiographers in Benin City exhibit strong foundational commitment to pediatric radiography best practices, evidenced by universal ALARA awareness, frequent technique adjustments, and proactive cooperation strategies. The alternative hypothesis is upheld, confirming that optimizedpractices reduce radiation doses, aligning with global imperatives for child safety. However, disparities in specialized training, equipment access, and environmental support reveal a KAP-like disconnect, where positive intent outpaces consistent application. These findings underscore the potential for enhanced protocols to safeguard vulnerable pediatric patients, fostering diagnostic accuracy and long-term health in Nigeria's evolving healthcare landscape.

5.4 Implications of the Study

The study has multifaceted implications. For practice, it highlights the urgency of integrating pediatric modules into radiography training at institutions like the University of Benin, potentially reducing repeat exposures by 25-30% (Zewdu et al., 2017). Policy-wise, it advocates for nationalguidelines mandating DRLs and CPD, informing RRBN standards. For patient care, emphasizing parental involvement and low-dose techniques promotes equity, particularly in teaching hospitals(57.50% of sample). Theoretically, it extends the Health Belief Model (Shubayr, 2024) and Diffusion of Innovation (Rogers, as cited in Chapter Two) by demonstrating how perceived barriers hinder adoption in low-resource contexts, guiding behavior-change interventions.

5.5 Recommendations

Based on the findings, the following recommendations are proposed:

1. **Training Enhancement**: Implement mandatory annual workshops on pediatric protocols, including simulation-based ALARA application, targeting early-career radiographers(70.00% of sample).
2. **Infrastructure Upgrades**: Equip facilities with child-friendly environments and immobilization aids, prioritizing teaching hospitals to address 50.00% environmental gaps.
3. **Policy Development**: Establish Nigeria-specific DRLs for pediatrics, with routine audits to ensure 100% guideline alignment, collaborating with bodies like the Nigerian Society of Radiographers.
4. **Research Integration**: Incorporate findings into UBTH protocols, promoting low-dose techniques (55.00% favored) to minimize doses.
5. **Parental Engagement**: Standardize guidelines for parental presence, leveraging 80.00% perceived benefits to reduce anxiety without over-relying on sedation.

5.6 Limitations of the Study

This study has notable limitations. The census sampling (n=40) from Benin City limits generalizability to broader Nigerian contexts, potentially underrepresenting rural or northern facilities. Self-reported data may introduce bias, as social desirability could inflate adherence claims (e.g., 100% ALARA familiarity). The cross-sectional design precludes causality assessments, such as direct dose reductions from practices. Additionally, the absence of objective measures (e.g., actual dose audits) relies on perceptions, and the focus on radiographers excludes multidisciplinary views. Future studies could mitigate these through mixed methods and larger, national samples.

5.7 Suggestions for Further Research

Building on this study, the following areas warrant exploration:

1. **Longitudinal Impact Assessment**: Evaluate the long-term effects of simulation training on dose reduction and image quality in pediatric radiography at UBTH.
2. **National Comparative Study**: Compare pediatric practices across Nigeria's geopolitical zones to identify regional disparities and scalable interventions.
3. **Multidisciplinary KAP Analysis**: Investigate knowledge, attitudes, and practices among radiologists, nurses, and pediatricians in collaborative imaging teams.
4. **Technology Adoption Efficacy**: Assess the role of digital radiography in overcoming equipment barriers, measuring pre/post-implementation dose outcomes.
5. **Anxiety Quantification**: Use validated scales to measure anxiety reduction via child-friendly strategies, correlating with repeat scan rates.

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QUESTIONNAIRE

Dear Participant,

I am Ashiru Samuel, a final year undergraduate radiography student at University of Benin. I am conducting a research study on The Use of Radiography in Pediatric Patients: Best Practices.

Your participation in this study is entirely voluntary, and all your responses will be kept confidential and used strictly for academic research. There are no right or wrong answers, and your honest responses will greatly contribute to the success of this research.

Thank you for your valuable time and cooperation.

Section A: Demographic Information

1. Age:[ ] 20-29 [ ] 30-39 [ ] 40-49 [ ] 50-59 [ ] 60 and above

2. Gender: [ ] Male [ ] Female

3. Years of Experience: [ ] 1-2 years [ ] 3-5 years [ ] 6-10 years [ ] 11-15 years [ ] 16 years and above

4. What is your highest qualification?: [ ] DCR/DIR [ ] B.Sc [ ] M.Sc [ ] PhD

5.Place of work: [ ] private facility [ ] Specialist Hospital [ ] Teaching Hospital [ ] Other

Section B: Best Practices and Techniques Associated with Pediatric Radiography

6. Do you have any pediatric-specific radiography training? [ ] Yes [ ] No [ ] Maybe

7. Do you adjust exposure settings specifically for pediatric patients? [ ] Always [ ] Sometimes [ ] Never

8. Are you familiar with the ALARA principle? [ ] Yes [ ] No [ ] Maybe

9. Do you use immobilization devices during pediatric imaging? [ ] Always [ ] Sometimes [ ] Never

10. Are gonadal shields routinely used during pediatric X-rays in your department? [ ] Yes [ ] No [ ] Maybe

11. Which patient positioning methods are most commonly used in your pediatric practice? [ ] Supine [ ] Prone [ ] Erect [ ] Lateral decubitus

12. How often do you encounter challenges in acquiring quality pediatric radiographs? [ ] Always [ ] Often [ ] Sometimes [ ] Rarely [ ] Never

Section C: Suitable Techniques to Counter Challenges (Nigeria & Global Standards)

13. Do you believe that adopting global pediatric imaging guidelines (e.g., ALARA, Image Gently) improves practice outcomes?

[ ] Yes [ ] No [ ] Maybe

14. How often are international standards referenced or applied in your facility's pediatric radiography protocols? [ ] Always [ ] Sometimes [ ] Never

15. Do you think Nigeria's pediatric radiography practices align adequately with global standards? [ ] Yes [ ] No [ ] Maybe

16. Which of the following techniques do you consider most effective in minimizing radiation exposure in pediatric patients? [ ] Beam collimation [ ] Use of gonad shielding [ ] Low-dose techniques [ ] Filtration

17. Do you receive regular training or updates on global pediatric radiographic standards? [ ] Yes [ ] No [ ] Maybe

18. Do you think the availability of advanced imaging equipment in your facility helps overcome challenges in pediatric imaging? [ ] Strongly agree [ ] Agree [ ] Neutral [ ] Disagree [ ] Strongly disagree

Section D: Strategies for Enhancing Patient Cooperation and Reducing Anxiety

19. Do you involve parents/guardians during imaging to help calm children? [ ] Always [ ] Sometimes [ ] Never

20. Do you use child-friendly communication or play methods to reduce anxiety? [ ] Yes [ ] No [ ] Maybe

21. Is sedation used for non-cooperative pediatric patients? [ ] Always [ ] Sometimes [ ] Never

22. Does your department have a child-friendly imaging environment? [ ] Yes [ ] No [ ] Maybe

23. Do you receive training on handling pediatric patients to improve cooperation during radiographic procedures? [ ] Yes [ ] No [ ] Maybe

24. Do you think parental presence during pediatric radiography reduces a child's anxiety? [ ] Yes [ ] No [ ] Maybe