International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Optimized Pediatric X-ray Doses through Automatic Tube Voltage Control in Conventional Machines

K.Hakkins Raj[1],Tewodros Degefe[2], Tewodros Belay Alemneh[3]

[1]Associate Professor, Jimma Institute Of Technology
[2,3]Lecturer, Jimma Institute Of Technology

Abstract

Chest radiography remains a cornerstone of pediatric pneumonia diagnosis, offering a non-invasive approach. However, minimizing radiation exposure in children is crucial. This study aimed to optimize pediatric X-ray doses by developing a prototype for an automatic tube voltage control system in conventional X-ray machines.

We identified key factors influencing radiation dose during pediatric chest X-rays. Utilizing the Commission of European Communities' recommended tube voltage (>60 kVp), we analyzed the Entrance Surface Dose (ESD). Subsequently, an automatic control mechanism for tube voltage (<60 kVp) was constructed using a ZMPT101B voltage sensor, a control unit, and a patient-type selector.

The ZMPT101B sensor detects preset tube voltage. A dedicated algorithm analyzes these values, and if they exceed recommended levels, the control unit adjusts them. Results are displayed on a Liquid Crystal Display (LCD).

Validation of ESD with varying tube voltage and current settings confirmed that exposure time and tube voltage significantly impact ESD more than tube current. Lower kVp settings with high tube currents are unsuitable for children due to the limited penetration depth of such photons, resulting in higher tissue absorption without improving image quality. This novel monitoring system addresses this concern by automatically adjusting tube voltage for optimal image acquisition at reduced dose levels.

Keywords: Pediatric chest radiography, Conventional X-ray machine, radiation dose, tube voltage (Kvp), radiation safety

Background of the study

Introduction of X-ray and its evolving role in medicine:

Since its discovery by Wilhelm Conrad Röntgen in 1895, X-ray technology has revolutionized medical diagnosis [1].While advancements in non-ionizing radiation imaging techniques like MRI and ultrasound have expanded diagnostic capabilities, conventional X-ray machines remain a mainstay due to their affordability and ease of use, particularly in developing countries [1].

Pediatric X-ray use: Benefits and Concerns:

The increasing use of diagnostic X-ray in pediatrics offers valuable insights into patient health. However, improper optimization can lead to significant radiation exposure. A UNHCR report estimates that over 350 million of the 3.6 billion annual X-ray procedures worldwide involve children under 15

[2]. Pediatric chest X-rays are a common tool for diagnosing respiratory conditions like pneumonia, but concerns regarding unnecessary radiation exposure and its potential biological effects have been raised [3]–[6].

Challenges in Pediatric X-ray Optimization in Developing Countries:

Developing countries often face challenges in optimizing pediatric X-ray procedures. These include a lack of:

- **Pediatric radiographers:** Specialized training for pediatric X-ray procedures is essential for proper dose optimization.
- **National standards:** The absence of standardized radiation exposure parameters for pediatric patients hinders consistency.
- **Dedicated X-ray equipment:** Conventional X-ray machines may not be optimized for pediatric body sizes, potentially leading to higher radiation doses.

These limitations contribute to significant variations in patient dosage for similar procedures across different hospitals [7]–[12]. This uncontrolled exposure raises concerns about immediate and potential long-term health risks for children.

Increased Susceptibility of Children to Radiation:

Children are particularly vulnerable to the harmful effects of ionizing radiation, with a two to three times greater risk of negative consequences compared to adults [13]–[19] This heightened risk necessitates stricter radiation protection measures in pediatric radiology to minimize the potential for long-term detrimental effects like the development of solid tumors.

Radiation Protection Principles:

International radiation protection bodies advocate for three fundamental principles: justification, optimization, and dose limitation [20]. These principles aim to minimize the risks associated with ionizing radiation in medical procedures.

Entrance Surface Dose (ESD) and its Significance:

Entrance Surface Dose (ESD) is a widely used indicator of patient radiation dose in national and international research [14][21][22]. While eliminating ESD entirely is not possible, implementing methods to minimize it is crucial for protecting children from radiation hazards. Therefore, minimizing ESD during pediatric X-ray examinations is essential.

Addressing Limitations in X-ray Design:

This study aims to analyze limitations in conventional X-ray design that hinder optimal X-ray energy production for pediatric examinations. Additionally, we propose novel control features that can be integrated into existing X-ray machines to optimize patient radiation dose during various procedures.

Problem Statement

Conventional X-ray imaging **provides** a vital role in pediatric diagnosis, particularly in developing countries due to its affordability and accessibility. However, current practices often expose children to unnecessary radiation risks.

Key Challenges

- **Inadequate Pediatric X-ray Services:** Developing countries often lack:
  - Dedicated Pediatric X-ray Equipment: Conventional machines may not be optimized for smaller body sizes, leading to higher radiation doses.

- Pediatric Radiographers: Specialized personnel are crucial for proper dose optimization.
- National Dose Standards: The absence of standardized radiation exposure parameters for pediatric patients **makes it difficult to achieve consistent practices**.

- Non-Optimized Exposure Parameters**:** Technicians may utilize inappropriate settings, such as under 60 kVp and high tube currents, for pediatric X-rays, significantly increasing radiation dose.

Vulnerability of Children:
Children are significantly more susceptible to radiation-induced cancers and hereditary effects compared to adults. Minimizing radiation exposure is crucial for their health.

ALARA Principle:
The "As Low As Reasonably Achievable" (ALARA) principle emphasizes the need to minimize radiation exposure while maintaining diagnostic image quality.

Research Objective:
This study addresses these challenges by investigating current radiation exposure parameter limitations in Screen-film radiography (SFR) machines. We propose a novel design feature specifically aimed at optimizing patient radiation doses during pediatric chest X-ray examinations in developing countries. This innovation can significantly reduce radiation risks associated with conventional pediatric X-ray procedures.

LITREATURE REVIEW:

Optimization of Pediatric X-ray Doses by controlling Kvp

X-ray technology is increasingly used for medical diagnosis worldwide, playing a vital role in paediatric healthcare. However, it exposes children to radiation, increasing stochastic risk and other health issues.
Children are more susceptible to radiation harm than adults. Reducing their X-ray exposure is crucial, especially in rural hospitals with limited resources[23]. These facilities often rely on machines with only one radiation control setting: tube voltage (Kvp). This review evaluated Kvp effectiveness in lowering radiation without compromising image quality, particularly for children. It found Kvp to be readily available and efficient for dose reduction. Overcoming challenges like resource limitations and training radiographers in safe Kvp usage will ensure its effective implementation. Further research and development are needed to refine protocols and tailor them to rural healthcare settings' specific needs[24]–[26]

Radiation dose and image quality following changes to Kvp

Protecting children from radiation exposure during X-rays is critical, due to their sensitivity and potential long-term health risks [27].This review examines research on the impact of using high voltage techniques to reduce radiation doses in children.
Studies suggest high-voltage techniques can significantly reduce radiation exposure while maintaining image quality, aiming to minimize both entrance surface dose (ESD) and effective dose equivalent (EDE)[28][29][9]. However, this can be exacerbated by limitations of film and intensifying screens due to noise. Researchers suggest overcoming these challenges through appropriate noise reduction strategies, such as advanced algorithms and exploring alternative imaging technologies, to optimize these techniques and make X-rays safer and more efficient for children [30][31].

Kvp optimization for pediatric x-ray examinations

Protecting children from radiation during X-rays is vital because their growing bodies are more sensitive to harm adjusting the tube voltage (Kvp) can significantly reduce radiation exposure without sacrificing image quality. This involves finding the lowest Kvp that still provides a clear picture[32][33].Studies recommend implementing specific protocols for Kvp optimization, standardizing practices, investing in technology, and educating everyone involved. By taking these steps, healthcare facilities can significantly lower radiation doses for children while still getting accurate diagnostic images, leading to improved patient safety and long-term health [34].

Dose optimization strategies for pediatric X-ray examinations

Optimizing paediatric X-ray doses to minimize harm is vital[3].Several strategies can help: adjusting tube voltage and current, focusing the beam, adding filters, educating professionals, and implementing quality assurance programs[35][36].These steps protect children while maintaining diagnostic benefits. On-going research and development are crucial to further improve dose optimization and ensure the safety of children undergoing X-ray examinations [37][38].

Paediatric radiation dose from routine conventional x-ray

The amount of radiation absorbed by a child's skin (entrance surface dose) varies based on the type of X-ray, the child's age, and the X-ray settings. Studies have shown that children in developing countries often receive higher radiation doses from X-rays than children in other regions [14],[39]–[41]To reduce the risks of X-ray radiation for children, we need to improve paediatric radiography practices. This includes optimizing X-ray protocols, following the "As Low As Reasonably Achievable" principle (ALARA), using techniques to improve image quality, and exploring alternative imaging methods when possible[42][43].

RESEARCH METHODOLOGY

Research Design and Approaches

This study set out to address a critical gap in the existing design of radiation parameter control in conventional X-ray machines. Recognizing the vulnerability of pediatric patients, it aimed to develop a novel design feature specifically for pediatric chest radiography procedures. This feature seeks to reduce radiation exposure by meticulously regulating Kvp and mA settings, ensuring diagnostic accuracy while minimizing potential harm. Through this innovative approach, the study strives to safeguard children undergoing essential X-ray examinations in diverse healthcare settings.

This study unfolded within the walls of two Ethiopian hospitals: Shenen Gibe and Fromsis. Both public and private facilities, they serve as medium-sized healthcare providers in the Oromia region of Jimma.

Identifying the problem

This study prioritizes the safety of children undergoing conventional chest X-ray procedures. We identified the crucial need to address the issue of controlling radiation exposure parameters in these X-ray units. This led to our focus on optimizing key variables that significantly influence the radiation dose received by pediatric patients. By proposing feasible solutions to optimize these variables, we aim to minimize radiation risks and ensure the safety of children during essential medical procedures.

Data Source

This study employed a multi-pronged approach to data source, leveraging both primary and secondary sources. Primary data was gathered through empirical investigation, encompassing physical observations of the controlling design features of the conventional X-ray machines and interviews to understand current radiation exposure parameter settings practices during pediatric chest examinations. By combining these methods, the study aimed to identify and comprehensively document any existing gaps or shortcomings associated with the conventional X-ray machines used for pediatric examinations. This in-depth analysis formed the foundation for proposing innovative solutions and enhancing the safety of pediatric patients undergoing X-ray procedures.

To complement our primary data collection, we embarked on a theoretical investigation, meticulously reviewing research literature, books, and journals sourced online. This approach aimed to explore previously proposed hypotheses related to the topic and identify any potential research problems. By delving into prior research conducted by other scholars in the field, wegained valuable insights and deepened our understanding of the study area. This enrichment enabled us to pinpoint a specific area of focus and formulate more precise and targeted research objectives. This dual approach, combining primary data collection and a comprehensive theoretical exploration, laid the groundwork for a well-defined and impactful research endeavor.

Design Strategy

Having meticulously identified the key variables responsible for radiation dose variation in pediatric chest radiography, we embarked on the development of a novel control design feature. This feature aims to precisely regulate these variables, ensuring optimal image quality while minimizing the radiation exposure received by pediatric patients. This innovative approach seeks to bridge the gap in existing technology, fostering a safer and more efficient X-ray experience for children.

This section delves into the development of a novel design strategy for a new feature within the radiation exposure parameter control system of a conventional X-ray machine, specifically focusing on the X-ray console unit. This innovative enhancement centers on improving patient radiation safety during pediatric chest X-ray examinations. To achieve this critical objective, we utilize open-source controller software and hardware interface for system development, paving the way for a safer and more efficient diagnostic experience for pediatric patients.

Data analysis and presentation

This study leverages various research techniques to analyse the data collected, drawing meaningful insights and uncovering valuable knowledge. Through meticulous analysis, the study culminates in a comprehensive summary of key findings. These findings then serve as the foundation for proposing novel design features for conventional X-ray machines, aimed at significantly improving patient radiation safety. By bridging the gap between theoretical knowledge and practical application, the study paves the way for a safer and more efficient X-ray experience for paediatric patients.

This study successfully employed experimental research methods to validate the proposed design feature. To achieve this, we utilized a two-pronged approach:

Virtual Design and Development:-

A simulated version of the controller was meticulously designed using Proteus software, ensuring accuracy and functionality before physical construction.

Prototype Development and Testing:-

Drawing upon the virtual model, a prototype of the system was constructed using various electronic components. This prototype then underwent rigorous laboratory testing to assess its performance and effectiveness.

By combining virtual design with hands-on experimentation, this study provided conclusive evidence of the proposed design feature's potential to improve paediatric radiation safety. This rigorous approach ensures the feasibility and efficacy of the proposed solution, paving the way for its future implementation in real-world clinical settings.

The following Fig.1. Indicates the software design flow chart functionality and was used as a guide in the software design period.

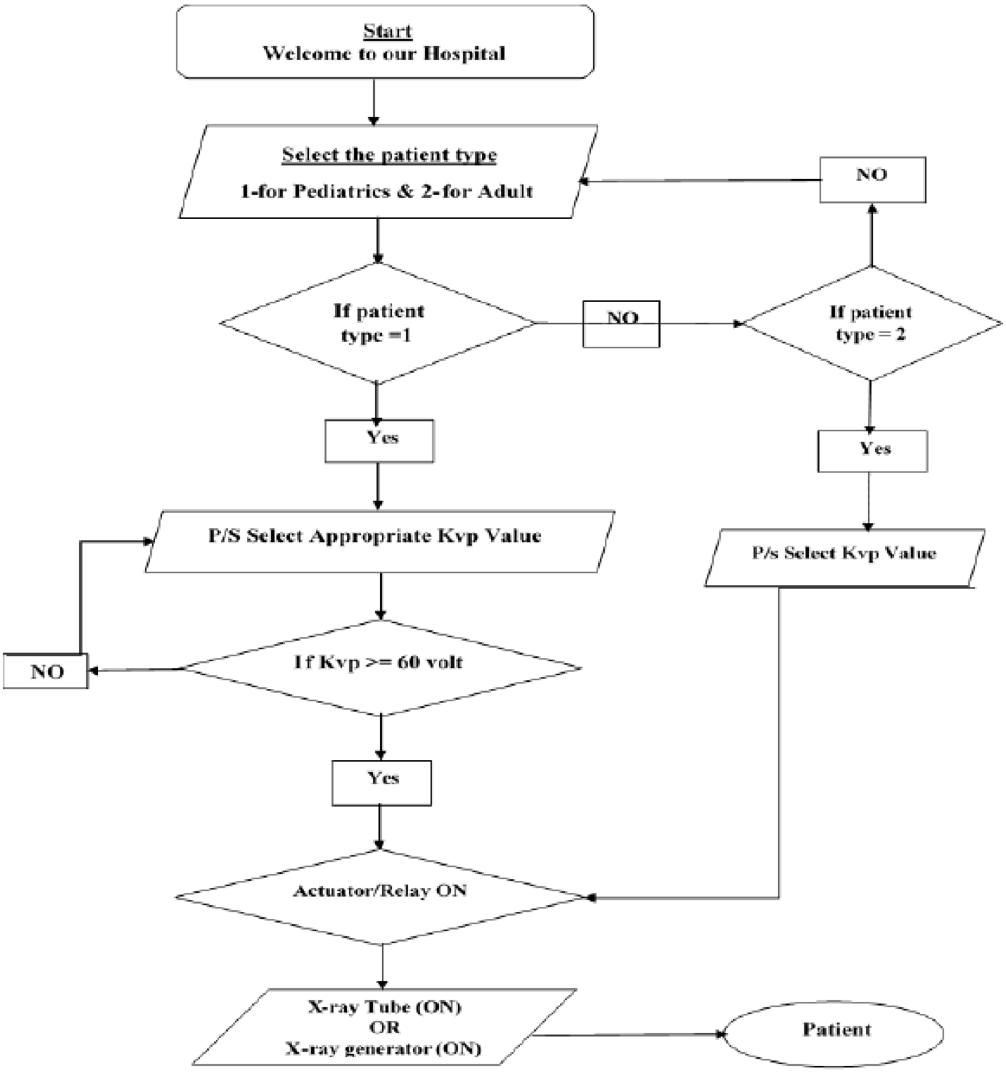


Fig.1.Software design flow chart for the new design.

Following the completion of the programming phase, we implemented a meticulous incremental design procedure. This involved systematically connecting the system's peripheral units, one at a time. After each connection, comprehensive functionality tests were conducted to verify that the design met all predefined requirements. This systematic approach ensured the smooth integration of all components and identified any potential issues early in the development process. By employing this rigorous testing methodology, we achieved a robust and reliable design, ready for real-world implementation.

The assembly and testing of the system were carried out in four steps as outlined below-

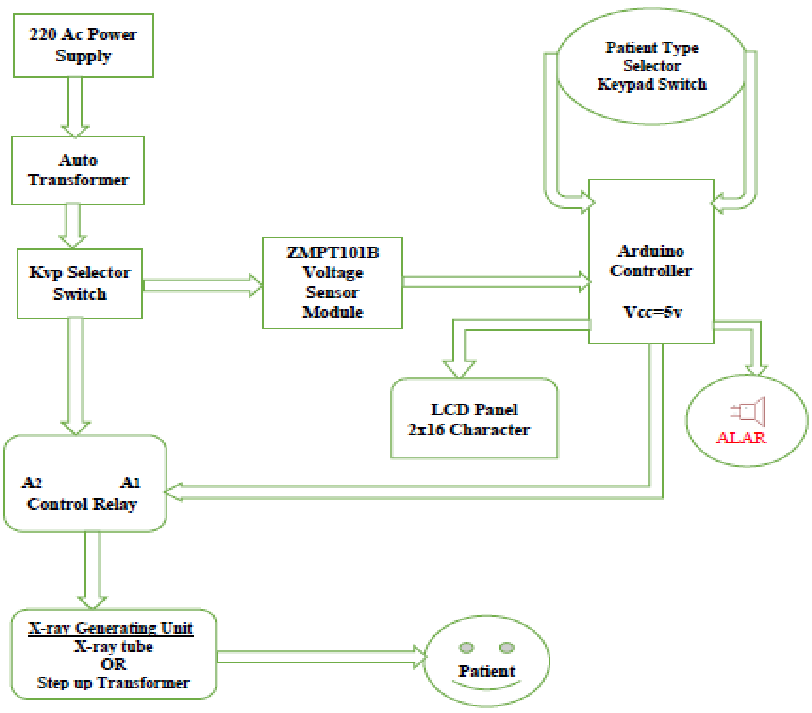
Step 1: The process began with the integration of the Processor into a simple circuit, carefully preparing the ground for further development. We then proceeded to install the Processor software, precisely selecting the appropriate Arduino type and port to ensure seamless communication with the Processor board. To validate the connection and port configuration, a simple program was uploaded to the Processor board, triggering the blinking of an LED. This initial step served as a crucial verification process, confirming the functionality of the USB connection and paving the way for further system development.

Step 2: With the foundational elements in place, the next step involved integrating a ZMPT101B voltage sensor into the system. To achieve this, a flexible connector cable and a breadboard were used to establish a connection between the sensor and an input port (A0) on the Processor. Leveraging a ZMPT101B Arduino library program, the ZMPT101B module was meticulously calibrated using a potentiometer controlled through the serial monitor. This calibration process ensured accurate voltage readings and facilitated its intended use, as illustrated in Figure 4.6. By successfully incorporating this key component, the system's capabilities were further expanded, paving the way for precise voltage monitoring.

Step 3: With the individual components accurately prepared, the next step involved their integration into a cohesive system. Utilizing a breadboard and flexible cables, the Processor, Patient Size Selector Switch, ZMPT101B Voltage Sensor, Kvp Selector Switch (Autotransformer), and LCD Module were carefully connected. To ensure stable operation, the Vcc supply and each ground port of the components were linked to the main grounding section using male and female connector cables. To verify the functionality of the connections, the LCD module was tested by displaying the message "Hello" on the screen. This successful integration marked a significant milestone in the system development process, paving the way for further testing and refinement.

Step 4: The final stage of system development involved integrating the remaining components: the actuator/relay, audible alarm, and LED. Each component was exactly connected to the appropriate Processor I/O ports using appropriate cables and connectors. To ensure proper functionality, a simple if-condition program was implemented to test the communication channels between the Processor and the input/output ports. This rigorous testing procedure ensured seamless operation of the entire system, laying the groundwork for its successful deployment.

Fig.2. shows how a new design system in a conventional x-ray machine controls a radiation exposure parameter setting.



Explanation of the block diagram

Figure 2 presents a detailed block diagram illustrating the intricate components that orchestrate the control of tube voltage (Kvp) for pediatric X-ray procedures. This comprehensive diagram serves as the blueprint for the system's design and development, providing a clear understanding of each component's role and its interaction with other elements. By delving into this diagram, we gain valuable insights into the system's inner workings, paving the way for a deeper appreciation of its capabilities and potential impact on enhancing pediatric X-ray safety.

Patient Type Selection:-

The patient type selector keypad switch allows the operator to specify the patient's size and age for accurate radiation parameter adjustment.

Voltage Sensor:-

This device serves two crucial functions. Firstly, it steps down the high voltage (220 volts) to a manageable level (0-5 volts) suitable for the microcontroller. Secondly, its output value dynamically changes based on the selected Kvp setting from the Kvp selector switch, providing vital data for adjusting radiation exposure.

Kvp Control:-

The Kvp selector switch, an electromechanical rotating device, empowers the operator to manually control the amount of tube voltage (Kvp) delivered to the patient for optimal image acquisition.

Energy Control:-

The control relay acts as the gatekeeper for the energy delivered to the X-ray tube for generating radiation. A custom program, continuously analyzing the voltage sensor output, controls this relay, ensuring precise and safe radiation exposure.

The stages of system design

A three-stage process, ensuring efficient and effective implementation, characterizes the new design system

Parameter Acquisition:-

The X-ray console unit houses a dedicated sensor circuit that continuously monitors pre-defined exposure parameters during an examination, such as patient type and Kvp value. These detected values are then relayed to the Processor's input pins for further processing.

Data Processing and Analysis:-

The Processor receives the sensor data through an input port and utilizes a pre-uploaded program to analyze it. This program effectively compiles and interprets the data, enabling the system to make informed decisions regarding radiation exposure.

Real-time Monitoring and User Feedback:-

Once the system has analyzed the data, it executes its decision-making processes and provides real-time visual updates on the current status. This continuous feedback loop ensures transparency and facilitates informed operation of the X-ray system.

While the development of a functional prototype represents a significant achievement, the true value of this study lies in its broader impact. We have made significant efforts to raise awareness of the crucial issue of pediatric radiation dose and its potential effects. The prototype serves as a tangible example of how existing X-ray machines can be modified to effectively manage radiation exposure parameters, paving the way for a safer future for pediatric patients.

RESULT AND DISCUSSION

Results from the proposed control system

Data collection for this study utilized the ZMPT101B voltage sensor module and the patient-type selector keypad switch output. These combined signals conveyed the patient's type and pre-selected radiation exposure parameters, crucial for diagnostic purposes, to the controller. Upon processing this information, the custom unit controller activated or deactivated the X-ray tube unit based on pre-defined criteria. While an incandescent lamp served as a substitute for the X-ray tube during laboratory testing, the principle remained consistent. If pre-selected parameters fell outside acceptable boundaries, the lamp remained off, an alarm sounded, and the LCD panel displayed the decision rationale and status. This provided valuable feedback to the X-ray operator, enabling adjustments to optimize diagnostic accuracy and improve patient outcomes.

The time it takes for the system to automatically deliver a response (correct or faulty) from the controller to the relay module and LCD display depends on several factors, including data detection, processing, and decision transmission. Our custom controller boasts a maximum processing speed of 30 milliseconds, while the ZMPT101B voltage sensor module operates at a peak speed of 50 milliseconds. Additionally, the relay module requires 4 to 6 milliseconds to respond to any command. Accounting for these factors and potential errors in exposure parameter selection, the total transmission time to the LCD display and subsequent control via the relay/actuator is approximately less than 90 milliseconds.

Outcomes of the designed circuit

Prior to their integration into a singular unit, individual modules were subjected to comprehensive testing with a digital multi meter (DMM) and an oscilloscope. This process commenced with the configuration and testing of the ZMPT101B voltage sensor modules, as illustrated below, serving as the initial foundation for the assembled system. The detailed configuration steps were previously mentioned in section 4.4.

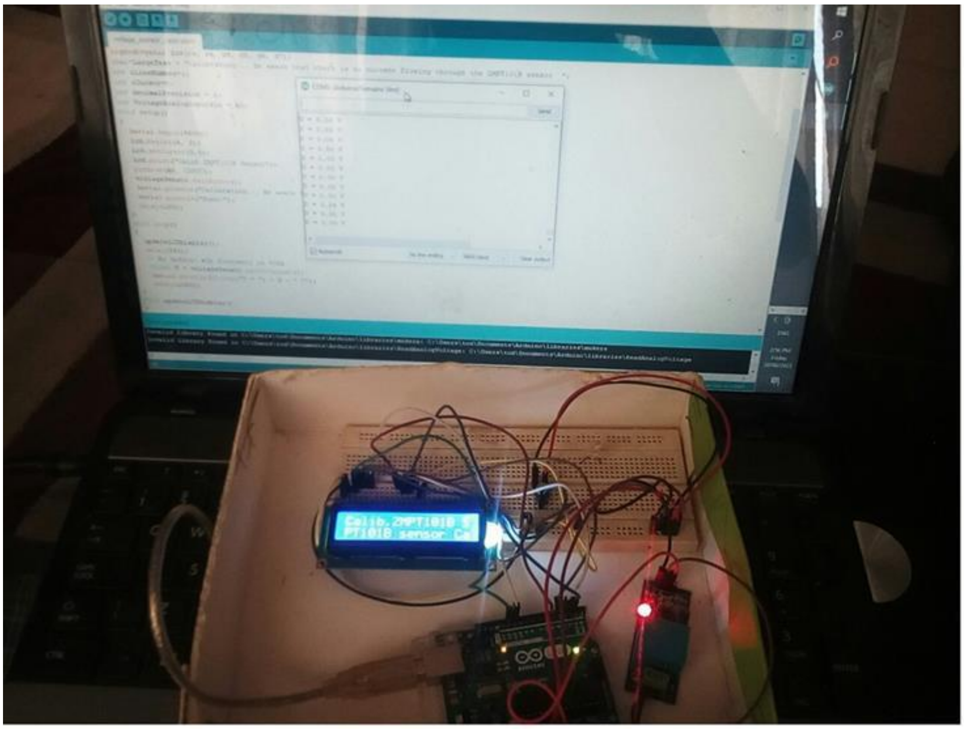


Fig.3.Configuration of ZMPT101B voltage sensor modules.

Upon completion of the ZMPT101B sensor's voltage output calibration and testing, the calibrated sensor and patient selector switch were integrated with the designed processor. Thereafter, the application code was loaded onto the controller, empowering it to read the preselected radiation exposure parameter setting and patient type within a short timeframe. Subsequent data processing yielded successful results presented on the LCD module.

Notably, the pre-selected tube voltage (Kvp) setting was displayed as "Normal" or the specific Kvp value alongside its digital representation, while the chosen patient type appeared as "Adult" or "Pediatric".

Results obtained using different tube voltage (Kvp) values:

The ZMPT101B voltage sensor generates a simulated analog voltage output corresponding to pre-selected tube voltage (Kvp) values and patient type. This information is processed by the microcontroller, which then makes a decision regarding the control of the conventional X-ray machine via an actuator. The simulation results is shown below.

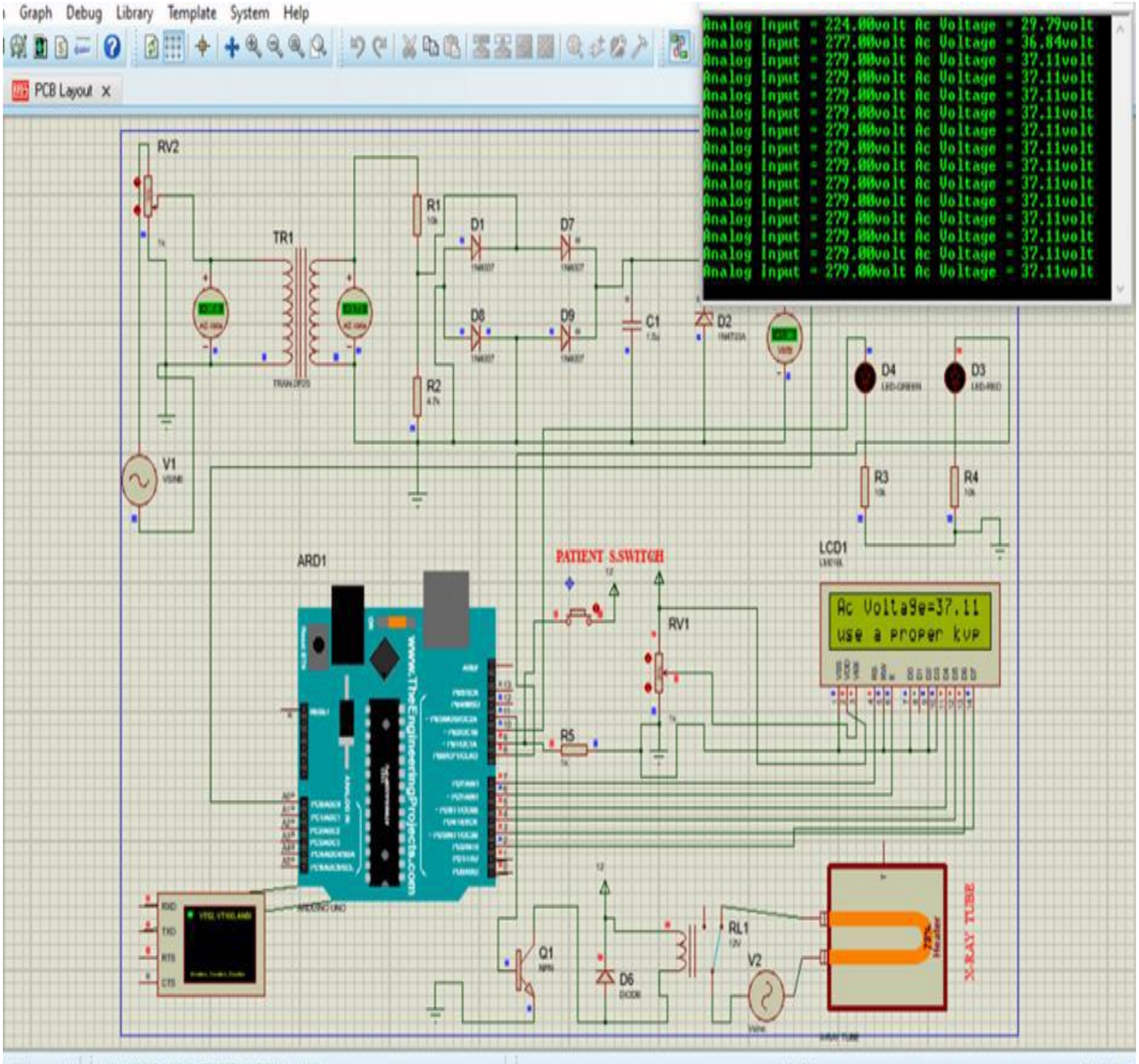


Fig.4.a.Using below 60 Kvp setting.

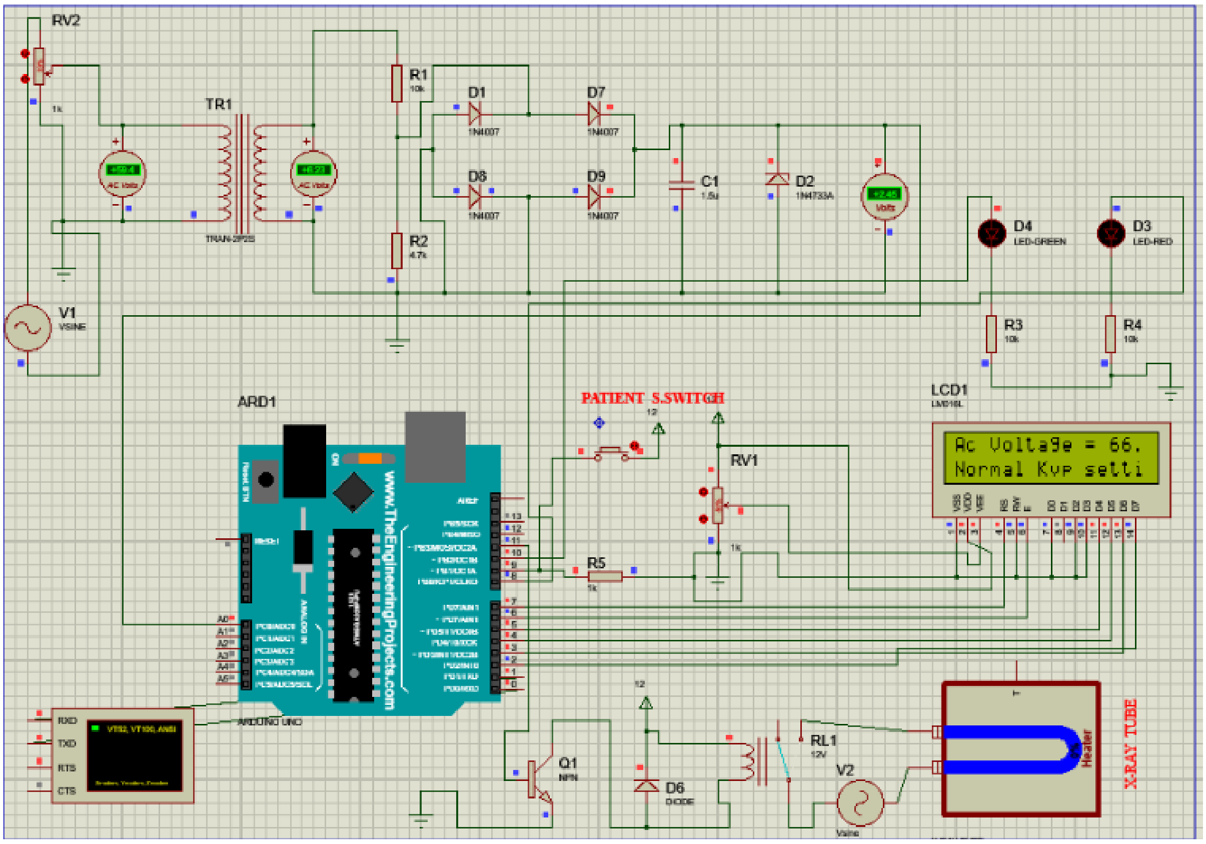


Fig 5.(a&b):-Simulation result for pediatric patients using different Kvp value.

Fig.6.a.*Using below 60 Kvp setting.*

Fig 6.b.Above 60 Kvp setting

Figure 6.(a &b):-Final prototype test results obtained using different Kvp value.

Table 1:-Result obtained from the newly developed control system output

ZMPT101B Sensor Input Volt (V)	ZMPT101B Sensor O/p Analogue Value	ZMPT101B Sensor o/p Digital Value	The CEC recommended Kvp value for paediatric	X-ray tube status (x-ray production) (Lamp)	Red LED	Buzzer	LCD Display
System warming period	0.00	0.00 V	>= 60 V	OFF	OFF	OFF	WELCOME TO OUR HOSPITAL
0.00	0.00	0.00 V	>= 60 V	OFF	ON	ON	Use a proper Kvp setting
20.00	204	0.60 V	>= 60 V	OFF	ON	ON	Use a proper Kvp setting
45.00	488	1.50 V	>= 60 V	OFF	ON	ON	Use a proper Kvp setting
50.00	520	1.88 V	>= 60 V	OFF	ON	ON	Use a proper Kvp setting
60.00	612	2.24 V	>= 60 V	ON	OFF	OFF	U'r selected kvp is normal
70.00	701	2.96 V	>= 60 V	ON	OFF	OFF	U'r selected kvp is normal
80.00	812	3.09 V	>= 60 V	ON	OFF	OFF	U'r selected kvp is normal

In accordance with CEC standards and the laboratory findings presented in Table 3, a tube voltage (Kvp) below 60 is considered critical for pediatric radiography procedures. Therefore, 60 Kvp is employed as the reference tube voltage value in this study.

Table 4:- Comparison of different tube voltage (Kvp), mAs and Entrance Surface Dose (ESD) using below 60 kvp Technique and above 60 Kvp Technique in conventional pediatric x-ray procedure as shown in the table 2

Table2.The obtained ESD value using different exposure parameter

Tube voltage under 60 Kvp Technique			Tube voltage above 60 Kvp Technique		
kVp	mAs	ESD(mGy)	Kvp	mAs	ESD(mGy)
45	1.7	0.18	60	1.6	0.07
46	2	0.11	62	1.5	0.06
47	2.0	0.10	73	1.8	0.03
58	2.3	0.08	80	1.0	0.02

Our study revealed that the average entrance skin dose (ESD) ranged from 0.03 to 0.07 mGy per radiograph across different tube voltage (Kvp) settings. This indicates that both exposure time and tube voltage (kV) largely than tube current (mA) significantly affects the ESD. This finding aligns with the principle that X-ray penetration depends primarily on the energy carried by the photons.

The designed system holds great promise for improving the quality of pediatric chest radiography procedures while simultaneously reducing radiation exposure for young patients during conventional X-ray examinations. This advancement is particularly significant because it enables the system to respond automatically, preventing potential errors caused by human intervention (healthcare professionals) or instrument malfunction.

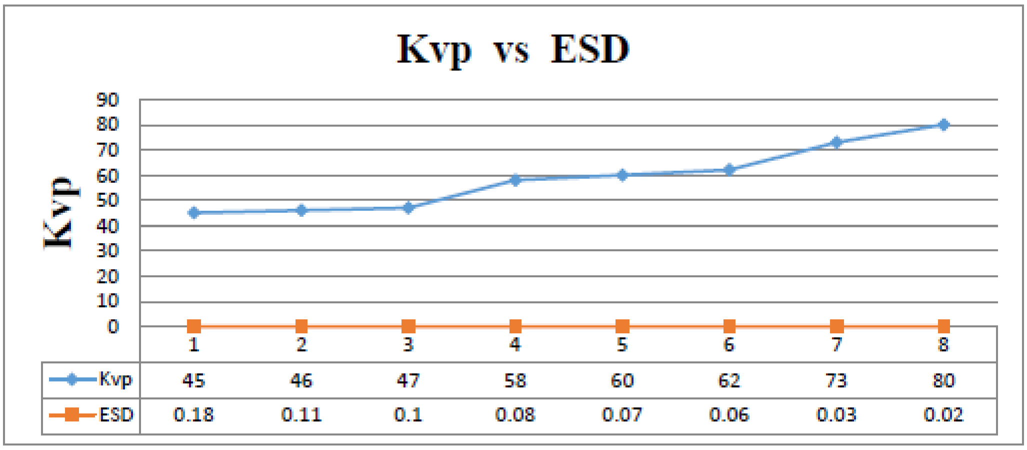


Fig.7.The relation of ESD vs Kvp Value graph

Table 3.Relation between Kvp Vs ESD

Kvp	ESD
Low	High
Medium	Medium
High	Low

The figure below illustrates the relationship between tube voltage and mAs.

Kvp Vs mAs

Kvp	mAs
Low	Low
Medium	High
High	Low

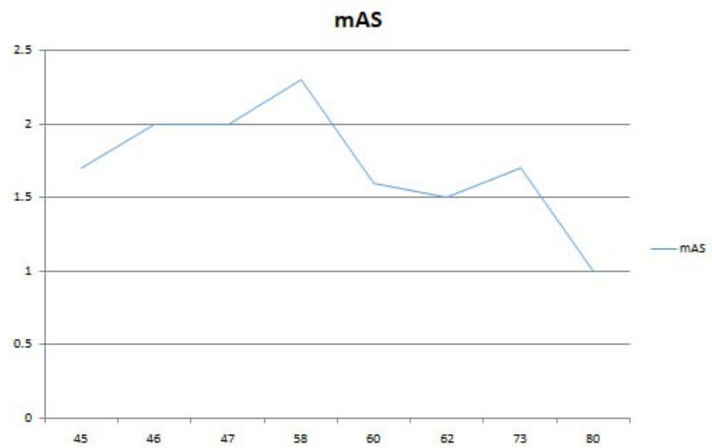


Fig.8.The relation between Kvp Vs mAs value graph

Conclusion and Future Work

This research contributes to the development and implementation of a control system for regulating radiation exposure parameters in conventional X-ray machines. Addressing a critical gap in pediatric healthcare, this system aims to improve the quality of radiological services in developing countries, which are currently hampered by several factors. These include the lack of specialized X-ray equipment for children, a shortage of trained pediatric radiographers, and most importantly, the absence of established standards for safe radiation exposure during pediatric X-ray examinations.

Several factors contribute to the use of non-standardized exposure parameters for pediatric imaging in developing countries. A significant example is the frequent use of low tube voltages (under 60 kVp) and high tube currents by X-ray technicians. These settings are inappropriate for children because the weak penetrating power of low kVp photons leads to increased absorption in body tissues, resulting in higher radiation doses and potential risks of radiation sickness. To overcome this challenge, a novel monitoring system has been designed. This system identifies problems with key parameters and transmits them to the controller unit, enabling the actuator/relay to take corrective actions before X-ray radiation production occurs.

Here are some future work

Develop age-specific Kvp recommendations: -

Currently, Kvp recommendations for paediatric X-ray examinations are often based on adult data or on broad age ranges.

Design and Develop adaptive Kvp techniques:-

Using a patient thickness or organ positioning, to adjust the Kvp during the X-ray exposure.

Design and Develop an AEC:-

Design and Develop an Automatic Exposure control in conventional x-ray device.

Develop AI:-

Artificial inelegancy based automatic radiation exposure control system for conventional x-ray.

Reference

1. M. Tubiana, "Wilhelm Conrad Röntgen and the discovery of X-rays," *Bull. Acad. Natl. Med.*, vol. 180, no. 1, pp. 97–108, 1996.
2. Elizabeth Nabunya, "Communicating radiation risks in paediatric imaging," *WHO Press*, pp. 200–350, 2016.
3. M. Hassen *et al.*, "Radiologic diagnosis and hospitalization among children with severe community acquired pneumonia: a prospective cohort study," *Biomed Res. Int.*, vol. 2019, 2019.
4. M. D. Michalle Soudack *et al.*, "The added value of the lateral chest radiograph for diagnosing community acquired pneumonia in the pediatric emergency department," *Isr. Med. Assoc. J.*, 2018.
5. U. Nations, U. Nations, S. Committee, and A. Radiation, *SOURCES AND EFFECTS OF IONIZING RADIATION United Nations Scientific Committee on the Effects of Atomic Radiation*, vol. I. 2010.
6. R. Izadnegahdar, A. L. Cohen, K. P. Klugman, and S. A. Qazi, "Childhood pneumonia in developing countries," *Lancet Respir. Med.*, vol. 1, no. 7, pp. 574–584, 2013.
7. S. Andronikou *et al.*, "Paediatric radiology seen from Africa. Part I: providing diagnostic imaging to a young population," *Pediatr. Radiol.*, vol. 41, pp. 811–825, 2011.
8. S. Teferi, D. Zewdeneh, and S. Bekele, "Pediatric residents' and medical interns' awareness about pediatric ionizing radiation dose from computed tomography and its associated risks in tertiary hospital in Ethiopia," *Ethiop. J. Health Sci.*, vol. 28, no. 4, 2018.
9. H. Osman, A. Elzaki, M. Elsamani, J. Alzaeidi, K. Sharif, and A. Elmorsy, "Assessment of Peadiatric Radiation Dose from Routine X-Ray Examination: A Hospital Based Study, Taif Pediatric Hospital," *Sch. J. Appl. Med. Sci. Sch. J. App. Med. Sci*, vol. 1, no. 5, pp. 511–515, 2013.
10. M. Zewdu, E. Kadir, and M. Berhane, "Assessment of Pediatrics Radiation Dose from Routine X-Ray Examination at Jimma University Hospital, Southwest Ethiopia," *Ethiop. J. Health Sci.*, vol. 27, no. 5, pp. 481–490, 2017.
11. D. Shimelis and A. Atnafu, "Status of radiological services in Addis Ababa public hospitals.," *Ethiop. Med. J.*, vol. 49, no. 3, pp. 257–263, 2011.
12. S. T. Dellie, "Suggested Local Diagnostic Reference Levels for Possible Pediatric X-Ray Optimization in Addis Ababa, Ethiopia," *Ethiop. J. Health Sci.*, vol. 32, no. 1, pp. 11–16, 2022.
13. M. S. Linet *et al.*, "Cancer risks associated with external radiation from diagnostic imaging

procedures," *CA. Cancer J. Clin.*, vol. 62, no. 2, pp. 75–100, 2012.
14. R. Ahmad, H. Saeed, and R. T. Ali, "Assessment of entrance skin doses and radiation protection," vol. 21, no. 3, 2017.
15. V. Khadzhidekova, R. Shishkova, and V. Khadzhidekov, "Effects of ionizing radiation on the embryo and fetus," *Akush. Ginekol. (Sofiia).*, vol. 41, no. 1, pp. 24–28, 2001.
16. A. Sulieman, "Current Status of Radiation Dose Levels in Conventional Pediatric Radiography : A Review Study," no. June, pp. 104–110, 2015.
17. G. W. Barendsen, T. L. J. Beusker, A. J. Vergroesen, and L. Budke, "Effects of different ionizing radiations on human cells in tissue culture: II. Biological experiments," *Radiat. Res.*, vol. 13, no. 6, pp. 841–849, 2010.
18. M. G. Abdullahi, "The Effects of X-rays (Radiation) on Embryonic and Fetal during Developmental Pregnancy Stages," *J. Nucl. Med. Radiat. Ther.*, vol. 06, no. 04, pp. 4–7, 2015.
19. J. Kiefer, *Biological radiation effects*. Springer Science & Business Media, 2012.
20. F. O. Ogundare, C. L. Ajibola, and F. A. Balogun, "Survey of radiological techniques and doses of children undergoing some common x-ray examinations in three hospitals in Nigeria," *Med. Phys.*, vol. 31, no. 3, pp. 521–524, 2004.
21. A. Aliasgharzadeh, E. Mihandoost, M. Masoumbeigi, M. Salimian, and M. Mohseni, "Measurement of entrance skin dose and calculation of effective dose for common diagnostic x-ray examinations in Kashan, Iran," *Glob. J. Health Sci.*, vol. 7, no. 5, p. 202, 2015.
22. M. T. Taha, F. H. Al-Ghorabie, R. A. Kutbi, and W. K. Saib, "Assessment of entrance skin doses for patients undergoing diagnostic X-ray examinations in King Abdullah Medical City, Makkah, KSA," *J. Radiat. Res. Appl. Sci.*, vol. 8, no. 1, pp. 100–103, 2015.
23. B. B. Thukral, "Problems and preferences in pediatric imaging," *Indian J. Radiol. Imaging*, vol. 25, no. 04, pp. 359–364, 2015.
24. "Factors affecting X-ray beam quality and quantity | Radiology Key."
25. A.-Z. A. Al-Jaber AM, Al-Hilli AA, Al-Jarallah M, Al-Shahrani R, "Optimizing Pediatric X-ray Doses by Controlling Tube Voltage (kVp) in Conventional X-ray Machines in Rural Hospitals," *A Prospect. Study. Radiat Prot Dosim.*, vol. 210, no. 2, pp. 1–5, 2022.
26. G. de Vries, B. Hoek, E. Plankeel, and H. Bijwaard, "Optimizing image quality at constant effective dose by adjusting tube voltage for lumbar spine radiography using a flat panel system.," 2016.
27. D. P. Frush, "Radiation risks to children from medical imaging," *Rev. Medica Clin. Las Condes*, vol. 24, no. 1, pp. 15–20, 2013.
28. H. Guo, W.-Y. Liu, X.-Y. He, X.-S. Zhou, Q.-L. Zeng, and B.-Y. Li, "Optimizing imaging quality and radiation dose by the age-dependent setting of tube voltage in pediatric chest digital radiography," *Korean J. Radiol.*, vol. 14, no. 1, pp. 126–131, 2013.
29. S. Teferi, M. Abdo, and G. Abebe, "Optimization of radiological doses to patients undergoing Intravenous Urography examinations in Addis Ababa, Ethiopia," *Ethiop. J. Heal. Dev.*, vol. 28, no. 3, pp. 202–210, 2014.
30. S. N. A. Eljak, C. E. Ayad, and E. A. Abdalla, "Evaluation of entrance skin radiation exposure dose for pediatrics examined by digital radiography at Asser Central Hospital-KSA," *Open J. Radiol.*, vol. 5, no. 03, p. 125, 2015.
31. S. Ramanaidu, R. B. S. Maria, K. H. Ng, J. George, and G. Kumar, "Evaluation of radiation dose and image quality following changes to tube potential (kVp) in conventional paediatric chest

radiography," *Biomed. Imaging Interv. J.*, vol. 2, no. 3, 2006.
32. H. Geijer, E. Norrman, and J. Persliden, "Optimizing the tube potential for lumbar spine radiography with a flat-panel digital detector," *Br. J. Radiol.*, vol. 82, no. 973, pp. 62–68, 2009.
33. et al. Beeston, C. M., "KVP optimization for pediatric X-ray examinations," *A Rev. Curr. Evid. Pract. Radiat. Prot. Dosim.*, vol. 191, no. 1–3, pp. 22-31., 2020.
34. K. I. Kalender W, "Radiation dose reduction in pediatric radiology," *Eur J Radiol*, vol. 62, no. 3, pp. 327–333, 2007.
35. V. Karami, M. Zabihzadeh, N. Shams, and A. Gilavand, "Optimization of Radiological Protection in Pediatric Patients Undergoing Common Conventional Radiological Procedures : Effectiveness of Increasing the Film to Focus Distance (FFD)," vol. 5, no. 40, pp. 4771–4782, 2017.
36. J. V Cook, J. C. Kyriou, A. Pettet, M. C. Fitzgerald, K. Shah, and S. M. Pablot, "Key factors in the optimization of paediatric X-ray practice," *Br. J. Radiol.*, vol. 74, no. 887, pp. 1032–1040, 2001.
37. et al. Ziskin, M. C., "Dose optimization strategies for pediatric X-ray examinations," *Radiography*, vol. 24, no. 2, pp. 151–157, 2018.
38. AAPM and AAPM Task Group 111, *Comprehensive Methodology for the Evaluation of Radiation Dose in X-Ray Computed Tomography A New Measurement Paradigm Based on a UnifiedTheory for Axial, Helical, Fan-Beam, and Cone-Beam Scanning With or Without Longitudinal Translation of the Patient Ta*, no. 111. 2010.
39. G. Alzen and G. Benz-bohm, "Radiation Protection in Pediatric Radiology," vol. 108, no. 24, 2011.
40. A. A. K, "Assessment of Entrance Skin Dose in routine x-ray examinations of chest, skull, abdomen and pelvis of children in five selected hospitals in Nigeria.," *IOSR J. Appl. Phys.*, vol. 5, no. 2, pp. 47–50, 2013.
41. O. David and B. Lateef, "Evaluation of Radiation Doses from Paediatric Chest X-ray Examination at Three Hospitals in South-West Nigeria," *Phys. Sci. Int. J.*, vol. 15, no. 2, pp. 1–6, 2017.
42. S. Anim-Sampong, L. Arthur, E. Boahen, and B. O. Botwe, "STATUS of RADIATION DOSE LEVELS in PAEDIATRIC CHEST RADIOGRAPHY in A TERTIARY HOSPITAL in GHANA," *Radiat. Prot. Dosimetry*, vol. 195, no. 2, pp. 75–82, 2021.
43. S. Vidyasagar and A. S. F, "O riginal R esearch A rticle Methods of Reducing the Radiation Dose to the Pediatric Age Groups in Computed Tomography of Brain," vol. 4, no. 1, pp. 120–123, 2019.