Journal of Health and Social Behavior Online First © The Author(s) 2025
ISSN: 0022-1465
Online ISSN: 02779536, 18735347

"Assessment of Radiation Dose Optimization Techniques in CT Scans: A Cross-Sectional Study"

Prepared by:

Naif Theaar Alotaibi
naieef48@gmail.com
Radiology Specialist
Turki menif alotaibi
Zeyid20@gmail.com
Radiology technician
Bandar Ahmad Ali Alassiri
bander222233@gmail.com
Radiology technician
Mshari mettab alamri
Mshari.alamri.m@gmail.com
Radiology technician

Journal of Health and Social Behavior Online First
ISSN: 0022-1465
Online ISSN: 02779536, 18735347

Abstract:

This study aims to explore the impact of family and social support on the severity of mental health symptoms among individuals in Saudi Arabia. The research will examine how the presence or absence of family and social support networks influences mental health outcomes, focusing on cultural, societal, and systemic factors specific to the Saudi context. Family support is hypothesized to play a significant role in alleviating symptoms, while the absence of such support may exacerbate mental health challenges. The study will employ a mixed-methods approach, combining quantitative data from surveys and qualitative data from semi-structured interviews. Through this approach, the study aims to identify key cultural and societal factors that may either enhance or hinder mental health recovery and provide recommendations for improving mental health treatment by strengthening support systems. The findings will contribute to a deeper understanding of the role of family and social networks in mental health care in Saudi Arabia and inform future mental health interventions and policies. **Keywords: Family support, social support, mental health, severity of symptoms, Saudi Arabia, cultural factors, societal factors, mental health recovery, stigma, cross-sectional study.**

Introduction

Computed Tomography (CT) has revolutionized medical imaging over the past decades, offering unparalleled detail in anatomical visualization and playing a vital role in the diagnosis, treatment planning, and follow-up of various diseases. However, one of the main concerns associated with CT imaging is the relatively high dose of ionizing radiation delivered to patients compared to other imaging modalities such as conventional X-ray or ultrasound (Smith-Bindman et al., 2009). With the global increase in CT usage—estimated at more than 80 million scans annually in the United States alone (Mettler et al., 2009)—concerns over radiation-induced cancer risks have become increasingly significant. Therefore, optimizing radiation dose while maintaining diagnostic image quality has emerged as a critical priority in the field of radiology.

Radiation dose optimization refers to the process of adjusting scanning parameters and employing advanced technologies to ensure that patients receive the minimum necessary radiation to achieve a diagnostically acceptable image. The guiding principle behind this effort is the ALARA concept—"As Low As Reasonably Achievable"—which advocates for minimizing radiation exposure without compromising diagnostic efficacy (ICRP, 2007). Several strategies have been developed and implemented in clinical practice to achieve this goal, including automatic exposure control (AEC), iterative reconstruction algorithms, protocol standardization, and tube current modulation (Kalra et al., 2004). These advancements have been supported by growing technological innovations in CT scanner hardware and software, facilitating more intelligent and adaptive imaging practices.

Iterative reconstruction (IR) techniques, for example, have shown significant promise in reducing image noise and enhancing image quality at lower radiation doses compared to traditional filtered back projection (FBP) algorithms (Singh et al., 2013). Modern IR algorithms—such as adaptive statistical iterative reconstruction (ASIR) and model-based iterative reconstruction (MBIR)—offer a trade-off between dose reduction and diagnostic performance, allowing radiologists to detect abnormalities with high confidence even at substantially reduced dose levels. Moreover, manufacturers are now integrating hybrid methods combining IR with deep learning technologies to further improve the diagnostic yield of low-dose imaging (Gong et al., 2018).

Another widely adopted method for dose optimization is automatic tube current modulation (ATCM), which dynamically adjusts the x-ray tube current during scanning based on the patient's size, shape, and anatomical region being imaged. Studies have demonstrated that ATCM can reduce patient dose by up to 40–60% without a significant loss in image quality (Matsunaga et al., 2012). Similarly, protocols tailored to specific clinical indications and patient populations—such as pediatric CT

Journal of Health and Social Behavior Online First © The Author(s) 2025
ISSN: 0022-1465
Online ISSN: 02779536, 18735347

protocols—have become essential tools for minimizing unnecessary radiation exposure in vulnerable groups (Frush et al., 2003).

Despite the availability of dose-reduction techniques, variations in their application persist across institutions, geographical regions, and even among individual radiologists and technologists. Inconsistent adherence to optimization protocols can lead to unnecessary radiation exposure and reduced image quality, affecting diagnostic outcomes and patient safety. Therefore, periodic evaluation of clinical practices and standard operating procedures is essential to ensure compliance with radiation protection standards and regulatory guidelines (McCollough et al., 2011). This evaluation must also include an assessment of the awareness, training, and attitudes of radiology personnel towards dose optimization strategies.

The importance of dose optimization in CT is underscored by numerous studies highlighting the potential long-term health risks associated with high cumulative radiation exposure. The biological effects of ionizing radiation are well-documented and include both deterministic effects, such as skin erythema and cataracts at high doses, and stochastic effects, such as cancer, which can occur even at lower doses (Brenner & Hall, 2007). Children, in particular, are at higher risk due to their increased radiosensitivity and longer life expectancy. For instance, a cohort study conducted in the United Kingdom found a statistically significant increase in the incidence of leukemia and brain tumors among children who underwent multiple CT scans (Pearce et al., 2012).

As such, the World Health Organization (WHO) and International Atomic Energy Agency (IAEA) have called for increased vigilance in the application of dose optimization practices in medical imaging. National and international campaigns, such as “Image Gently” and “Image Wisely,” have been launched to promote education, research, and awareness of safe imaging practices among healthcare providers and patients (Strauss & Goske, 2011). These initiatives emphasize the shared responsibility among radiologists, medical physicists, and radiologic technologists in ensuring the appropriate use of radiation in diagnostic imaging.

In addition to technological and procedural aspects, patient communication and justification of CT examinations play a significant role in dose optimization. Each CT scan must be clinically justified, with alternative imaging modalities—such as MRI or ultrasound—considered when appropriate. Furthermore, radiologists must remain engaged in protocol development and revision to align practices with evolving evidence and technological capabilities (NCRP, 2010).

Given the multifaceted nature of dose optimization, continuous research is needed to evaluate the real-world implementation of these techniques, particularly in diverse clinical settings and healthcare

Journal of Health and Social Behavior Online First © The Author(s) 2025
ISSN: 0022-1465
Online ISSN: 02779536, 18735347

systems. This study aims to assess the application of radiation dose optimization strategies in CT scanning within selected healthcare institutions, identify barriers to implementation, and propose actionable recommendations for improvement. By conducting a cross-sectional analysis of current practices, personnel awareness, and dose tracking data, this study seeks to contribute to the growing body of literature on radiation safety and enhance the quality of CT imaging services.

Research Problem:

Mental health issues have become a significant concern globally, and in Saudi Arabia, they are compounded by unique cultural and societal factors. While the role of family and social support in mental health recovery has been widely recognized in many contexts, there remains limited research on how these factors specifically influence the severity of mental health symptoms in Saudi patients.

In Saudi Arabia, where family bonds and social networks are crucial, the lack of adequate family and social support may exacerbate mental health symptoms, delay recovery, and increase the likelihood of relapse. Moreover, cultural stigma surrounding mental illness, as well as societal and systemic barriers, may prevent individuals from seeking professional help or discussing their condition with family members. The absence of a comprehensive understanding of these dynamics in the Saudi context presents a gap in mental health care that this study seeks to address.

Therefore, the central problem of this study is to explore how the presence or absence of family and social support impacts the severity of mental health symptoms among patients in Saudi Arabia, with a particular focus on the cultural, societal, and systemic factors that may influence these relationships.

Research Hypotheses:

1. **H1**: There is a significant negative correlation between the level of family and social support and the severity of mental health symptoms in patients in Saudi Arabia.
2. **H2**: Higher levels of family support are associated with better mental health outcomes and a reduction in the severity of mental health symptoms among patients in Saudi Arabia.
3. **H3**: The absence of social support networks (beyond family) is significantly correlated with worsened mental health symptoms among individuals in Saudi Arabia.
4. **H4**: Cultural and societal factors in Saudi Arabia (such as stigma and family roles) moderate the relationship between family/social support and mental health outcomes.
5. **H5**: Patients who report stronger family and social support networks are more likely to engage in mental health treatment and show improved recovery outcomes compared to those with limited support.

These hypotheses are designed to test the influence of family and social support on mental health symptoms, while considering the cultural and societal dynamics of Saudi Arabia.

Aim of the Research:

The aim of this research is to explore the impact of family and social support on the severity of mental health symptoms among patients in Saudi Arabia, focusing on the role of these supports in the mental health recovery process and identifying cultural, societal, and systemic factors that may enhance or hinder mental health outcomes.

Objectives of the Research:

1. To assess the level of family and social support among individuals diagnosed with mental health conditions in Saudi Arabia.
2. To examine the relationship between the presence or absence of family and social support and the severity of mental health symptoms among patients.
3. To explore the role of family dynamics in managing mental health conditions and its impact on symptom severity and recovery.
4. To identify cultural and societal factors that may influence the availability and effectiveness of family and social support in Saudi Arabia.
5. To investigate barriers within Saudi society that prevent individuals from seeking mental health treatment or discussing their mental health issues with their families.
6. To provide recommendations for enhancing the role of family and social support in mental health care and treatment in Saudi Arabia, based on findings from the study.

Research Limitations:

1. **Sampling Bias**: Since the study will be conducted in specific clinical settings in major cities of Saudi Arabia, the sample may not fully represent the broader population of individuals with mental health conditions across the country. This could limit the generalizability of the findings.
2. **Cross-Sectional Design**: As the study uses a cross-sectional design, it will provide a snapshot of the relationship between family/social support and mental health symptom severity at a specific point in time. However, it will not be able to establish causality or track changes in mental health over time.
3. **Cultural Sensitivity and Response Bias**: Given the cultural stigma surrounding mental health in Saudi Arabia, participants may underreport or overreport their experiences with

mental health symptoms or social support due to fear of judgment or societal expectations. This could affect the accuracy of the data.

4. **Language Barriers**: Although the study materials will be translated into Arabic, there may be challenges related to language nuances or misunderstandings of questions, especially when discussing sensitive mental health topics.
5. **Non-Response Bias**: There is a possibility that individuals who are more comfortable with or have greater access to social and family support will be more likely to participate, while those with limited support may not engage, leading to non-response bias.
6. **Time and Resource Constraints**: The study may be limited by time and resources, particularly when it comes to conducting in-depth interviews with a subset of participants. This may result in a smaller sample for the qualitative component, limiting the depth of insights.
7. **Generalizability to Other Populations**: The findings may not be directly applicable to other countries or regions with different cultural norms or healthcare systems. The research is focused specifically on Saudi Arabia and its cultural context, which may not be easily generalized elsewhere.

Study Terms and Definitions:

1. **Family Support**:
   Family support refers to the emotional, psychological, practical, and financial assistance provided by family members to an individual experiencing mental health issues. It can include help in daily tasks, emotional encouragement, and providing a sense of belonging and security.
2. **Social Support**:
   Social support involves the network of friends, colleagues, and community members who provide emotional, informational, and instrumental assistance to individuals. It includes both formal (e.g., healthcare professionals) and informal (e.g., friends, neighbors) support systems.
3. **Mental Health Symptoms**:
   Mental health symptoms refer to the indicators or manifestations of mental health conditions, which can include emotional, psychological, and behavioral changes such as sadness, anxiety, irritability, mood swings, and difficulty in daily functioning.
4. **Severity of Mental Health Symptoms**:
   This term describes the intensity or extent of mental health symptoms experienced by an individual. It can range from mild to severe and is typically measured using clinical scales or diagnostic tools that assess the frequency, duration, and impact of symptoms.

Journal of Health and Social Behavior

Journal of Health and Social Behavior Online First © The Author(s) 2025
ISSN: 0022-1465
Online ISSN: 02779536, 18735347

5. **Cultural Factors**:
   Cultural factors refer to the shared beliefs, customs, traditions, and values of a particular society that influence individuals' perceptions and behaviors. In the context of mental health, cultural factors in Saudi Arabia may include beliefs about mental illness, the role of family in treatment, and societal stigma surrounding mental health issues.
6. **Societal Factors**:
   Societal factors encompass the broader social, economic, and political conditions that impact individuals' lives, including access to healthcare, societal attitudes toward mental illness, and the availability of mental health resources. In Saudi Arabia, societal factors may include the influence of traditional values, religious beliefs, and the level of mental health awareness.
7. **Family Dynamics**:
   Family dynamics refer to the patterns of interactions, relationships, and roles within a family system. These dynamics, such as family communication styles, the roles of family members in caregiving, and emotional bonds, can significantly influence an individual's mental health and recovery process.
8. **Stigma**:
   Stigma refers to negative stereotypes, prejudice, and discrimination associated with a particular condition, such as mental illness. In Saudi Arabia, stigma related to mental health can prevent individuals from seeking help, disclosing their conditions, or receiving appropriate treatment from family or society.
9. **Cross-Sectional Study**:
   A cross-sectional study is a type of observational research design that collects data at a single point in time, providing a snapshot of the variables under investigation. It is useful for understanding the prevalence of an issue and the relationships between variables, but it cannot establish causality.
10. **Psychiatric Conditions**:
    Psychiatric conditions are mental health disorders or diseases that affect an individual's mood, thinking, behavior, and overall mental well-being. These conditions can include depression, anxiety disorders, schizophrenia, bipolar disorder, and other mood or personality disorders.
11. **Recovery Outcomes**:
    Recovery outcomes refer to the results or improvements in a patient's mental health status over time. These outcomes can include symptom reduction, improved functioning, and better overall well-being, influenced by factors like treatment, support systems, and personal coping strategies.

Journal of Health and Social
Behavior Online First © The Author(s)
2025
ISSN: 0022-1465
Online ISSN: 02779536, 18735347

12. **Informed Consent**:
    Informed consent is the process by which participants are given comprehensive information about a study, including its purpose, methods, potential risks, and benefits, and are asked to voluntarily agree to participate before any data collection takes place.

Theoretical Framework

The assessment of radiation dose optimization techniques in CT scans can be grounded in several theoretical perspectives that inform the development and application of these techniques in clinical practice. Central to these frameworks is the concept of **radiation protection and safety** (NCRP, 2010), which emphasizes minimizing the harmful effects of ionizing radiation while maintaining diagnostic accuracy. Several models and principles guide this research:

1. **ALARA Principle (As Low As Reasonably Achievable)**: This widely accepted radiation protection principle underpins most efforts to optimize CT imaging protocols. The principle asserts that radiation exposure should be minimized to the lowest possible level consistent with obtaining the required diagnostic information (ICRP, 2007). This approach balances the need for high-quality images with the imperative to reduce radiation-related risks.
2. **Risk Assessment Models**: The linear no-threshold (LNT) model, commonly used to estimate the risk of cancer and genetic mutations from radiation exposure, provides the foundation for evaluating the potential health impacts of CT scans (Brenner & Hall, 2007). The model assumes that the risk of radiation-induced cancer increases linearly with the dose, with no threshold below which exposure can be considered harmless. This model drives the need for dose optimization, particularly for vulnerable populations such as children and those requiring repeated imaging.
3. **Technological Innovation and Efficiency Models**: These models focus on the advancement of technology to enhance diagnostic performance while minimizing radiation dose. For example, iterative reconstruction (IR) algorithms represent a key technological development designed to reduce noise and improve image quality at lower radiation doses (Kalra et al., 2004). This approach is grounded in the theories of computational imaging, where algorithmic innovations can yield both technical and clinical improvements.
4. **Behavioral and Institutional Models of Compliance**: In the context of dose optimization, radiologists and technologists' behaviors play a significant role in whether best practices are implemented consistently across healthcare settings. Models from health behavior theory, such as the Health Belief Model and the Theory of Planned Behavior (Ajzen, 1991), suggest that a radiologist's attitudes, knowledge, and perceived barriers to radiation safety influence

their adoption of dose reduction protocols. Institutional frameworks also contribute to compliance with dose-reduction measures, with hospital policy, training, and leadership impacting practice standards.

In this study, the theoretical framework integrates these models to assess how dose optimization techniques are implemented in real-world clinical environments, factoring in technological, behavioral, and institutional elements. This multidimensional approach facilitates a holistic understanding of radiation dose optimization, considering both technological advancements and the human factors that influence clinical outcomes.

Previous Studies

A growing body of literature has investigated various radiation dose optimization techniques in CT imaging. These studies focus on both technological advancements and procedural practices aimed at reducing radiation exposure while preserving image quality.

1. **Automatic Exposure Control (AEC) Systems**: A significant number of studies have highlighted the role of automatic exposure control systems in reducing radiation dose. AEC adjusts the x-ray tube current based on the patient's body size, shape, and the specific anatomical region being imaged (Kalra et al., 2004). Matsunaga et al. (2012) demonstrated that AEC could reduce patient dose by up to 60% in routine CT scans without compromising diagnostic accuracy. Their study emphasizes the effectiveness of AEC in optimizing radiation dose, particularly in diverse patient populations, including those with varying body sizes.
2. **Iterative Reconstruction (IR) Techniques**: IR algorithms have become a cornerstone in dose optimization strategies. Singh et al. (2013) found that IR techniques, such as adaptive statistical iterative reconstruction (ASIR), could achieve similar or even better image quality at lower radiation doses compared to traditional filtered back projection (FBP) methods. Other studies, such as those by Kalra et al. (2004) and Mettler et al. (2009), have shown that IR significantly reduces image noise, which is crucial in maintaining diagnostic accuracy while lowering radiation exposure. In pediatric imaging, where minimizing radiation exposure is paramount, the use of IR has been particularly beneficial in achieving high-quality diagnostic images at reduced doses (Frush et al., 2003).
3. **Protocol Standardization and Customization**: Several studies have underscored the importance of customized imaging protocols tailored to specific clinical indications and patient characteristics. A study by Frush et al. (2003) showed that pediatric CT protocols, which use lower radiation settings and optimized imaging parameters, result in significantly lower radiation doses compared to adult protocols. Protocol standardization across

ISSN: 0022-1465
Online ISSN: 02779536, 18735347

institutions also ensures consistent application of dose-reduction strategies, improving overall patient safety.

4. **Radiation Dose Tracking and Reporting**: The use of dose-tracking software has become increasingly common in hospitals to monitor and record the radiation dose delivered during each CT scan. This technology allows clinicians and radiologists to assess whether the radiation dose is within safe limits and to adjust protocols accordingly. A study by McCollough et al. (2011) emphasized the role of dose-tracking systems in optimizing patient safety, as it enables the identification of any excessive dose patterns and the implementation of corrective measures. Moreover, integrating dose tracking with clinical decision support systems can guide healthcare providers in choosing the most appropriate imaging modality based on radiation concerns.
5. **Patient and Public Awareness**: A study by Strauss and Goske (2011) highlighted the impact of public health initiatives, such as the "Image Gently" campaign, which promotes the safe use of CT scans in pediatric populations. These campaigns raise awareness about radiation risks and emphasize the importance of minimizing exposure, especially for vulnerable groups. Additionally, patient education on the necessity and risks of CT imaging can lead to more informed decision-making regarding imaging procedures.
6. **Global Initiatives and Guidelines**: International organizations, such as the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA), have published guidelines emphasizing the importance of radiation protection in medical imaging. These guidelines advocate for the optimization of CT scan protocols and the incorporation of dose-reduction technologies, with a particular focus on high-risk populations (IAEA, 2017). A study by Pearce et al. (2012) found that increasing adherence to international radiation protection standards significantly decreased the incidence of radiation-induced cancers in populations exposed to frequent CT scans.
7. **Challenges in Dose Optimization**: Despite the widespread implementation of dose-reduction techniques, significant challenges remain in achieving consistent optimization across clinical settings. Variability in the application of dose-reduction protocols, differences in technological capabilities, and a lack of ongoing training for radiology staff have been identified as barriers to optimal dose reduction (McCollough et al., 2011). Furthermore, financial and logistical constraints in some healthcare systems may limit the adoption of newer technologies like iterative reconstruction.

Study Methodology

Research Design

The study follows a **cross-sectional design**, which provides a snapshot of the current state of radiation dose optimization in CT scans across different healthcare institutions. This type of study is suited to capturing practices, challenges, and the effectiveness of various dose optimization techniques at a given point in time. The goal is to evaluate the prevalence and consistency of dose reduction methods, the factors influencing their use, and their impact on radiation dose management.

Study Population and Sampling

1. **Population**:
   The primary population includes healthcare professionals involved in CT scanning, specifically **radiologists**, **radiologic technologists**, and **medical physicists**. These professionals are selected because they are directly responsible for implementing, overseeing, or advising on radiation dose management in CT imaging.
2. **Sampling Frame**:
   The study will target **public and private hospitals** that have **CT imaging departments**. Additionally, hospitals will be selected across **different geographic regions** to ensure diversity in the technological capabilities and institutional resources. Healthcare professionals working in these departments will be invited to participate.
3. **Inclusion Criteria**:
   - Hospitals with an active **CT department** performing diagnostic CT imaging.
   - Radiologists, technologists, and physicists who are involved in day-to-day CT scan operations, including those who supervise or are responsible for radiation dose protocols.
   - Hospitals or imaging centers that have implemented any form of **radiation dose optimization**, such as iterative reconstruction (IR), automatic exposure control (AEC), or dose tracking systems.
4. **Exclusion Criteria**:
   - Hospitals or clinics without a **CT imaging department** or those that do not routinely perform CT scans.
   - Healthcare professionals without direct involvement in CT scans (e.g., non-radiology staff).
   - Institutions that have not yet implemented any formal **radiation dose optimization techniques**.

5. **Sampling Method**:
   A **stratified random sampling** technique will be used to select both hospitals and healthcare professionals. Stratification will be based on **hospital type** (public vs. private) and **location** (urban vs. rural). This ensures that the sample includes hospitals of varying sizes, capabilities, and resources. In total, approximately **10-15 hospitals** will be selected, with **2-4 healthcare professionals** (radiologists, technologists, physicists) from each institution invited to participate in the survey.
6. **Sample Size**:
   The sample size will be calculated using **Cochran's formula for sample size determination**. Assuming a population of 1000 professionals working in CT imaging, with a 95% confidence level and a 5% margin of error, the estimated sample size will be approximately **280 healthcare professionals**. This number will be adjusted based on the final number of hospitals selected.

Data Collection Methods

1. **Survey Questionnaire**:
   A structured, **self-administered questionnaire** will be developed to collect **quantitative data**. The questionnaire will be designed with both **closed-ended** and **Likert scale** questions to assess the following:
   - **Demographics**: Participants' role, years of experience, education level, and professional training in radiation safety.
   - **Radiation Dose Optimization Practices**: Frequency of use of dose reduction techniques such as **AEC**, **IR**, and **dose tracking systems**.
   - **Knowledge and Attitudes**: Knowledge about radiation risks, familiarity with dose optimization guidelines, and attitudes toward the effectiveness of current dose-reduction technologies.
   - **Barriers and Challenges**: Perceived barriers to implementing dose optimization, including financial constraints, lack of training, and technical limitations.
   - **Institutional Support**: The presence of institutional policies, formal training programs, and the availability of resources for dose reduction.

   The questionnaire will be pre-tested with a small group of participants from a similar demographic to ensure clarity, reliability, and validity. **Test-retest reliability** will be conducted by administering the same survey to a small group of participants at two different times, and measuring the correlation between the two sets of results.

2. **Semi-Structured Interviews**:
   To complement the survey and gather **qualitative data**, in-depth **semi-structured interviews** will be conducted with key informants, including:
   - **Radiology department heads**.
   - **Senior radiologists** and **CT technologists**.
   - **Medical physicists** involved in radiation safety and optimization.

   The interviews will focus on:

   - **Decision-making processes** behind choosing dose optimization techniques.
   - **Institutional policies** regarding radiation safety and dose reduction.
   - **Challenges and barriers** faced in implementing radiation dose optimization, particularly technological, financial, and organizational obstacles.
   - **Suggestions for improving dose optimization** practices.

   Interview guides will be developed with open-ended questions, allowing for flexibility while ensuring coverage of key topics. Interviews will be audio-recorded with participants' consent, and **transcripts** will be analyzed for recurring themes, patterns, and insights.

3. **Radiation Dose Data Collection**:
   If available, **radiation dose data** will be extracted from the hospitals' **dose-tracking systems** or **radiology information systems (RIS)**. This data will include:
   - **Average radiation dose** for specific CT procedures (e.g., abdominal CT, chest CT, etc.).
   - **Dose metrics** such as **CTDI (Computed Tomography Dose Index)** and **DLP (Dose Length Product)** for commonly performed scans.
   - **Comparison** between hospitals using dose optimization technologies (like AEC, IR) and those that do not.

   If a dose-tracking system is unavailable or inadequate, data may be collected from the **radiology department** using documented protocols for specific scans, including radiation dose settings for those procedures.

Data Analysis

1. **Quantitative Data Analysis**:
   - Descriptive statistics will be used to summarize the characteristics of the study population, including demographic data and responses to the survey.
   - Frequency distributions and **mean scores** will be calculated to determine the most commonly used radiation dose optimization techniques, and the general knowledge and attitudes of healthcare professionals regarding radiation safety.
   - **Comparative Analysis**: Statistical tests such as **chi-square tests** or **independent t-tests** will be used to examine differences in practices and knowledge between different hospital types (public vs. private), or different geographic locations (urban vs. rural).
   - **Correlational analysis** will be used to assess the relationship between knowledge of radiation dose optimization and the use of dose reduction techniques.
2. **Qualitative Data Analysis**:
   - **Thematic analysis** will be used to analyze the interview transcripts. This approach involves identifying, analyzing, and reporting themes within the data. The process includes:
     - **Familiarization** with the data: Reading and re-reading interview transcripts to gain an overall understanding.
     - **Generating initial codes**: Coding relevant portions of the data to identify features of interest.
     - **Searching for themes**: Grouping codes into potential themes or patterns.
     - **Reviewing themes**: Refining and verifying themes to ensure they accurately represent the data.
     - **Defining and naming themes**: Finalizing the key themes and naming them to reflect their content.
   - NVivo or other qualitative data analysis software may be used to assist with organizing and managing the data.
3. **Radiation Dose Data Analysis**:
   - **Comparative Analysis**: Radiation dose data will be compared between hospitals using different dose reduction technologies. Statistical tests, such as **paired t-tests** or **ANOVA**, will be used to determine if the use of AEC, IR, or other technologies significantly reduces radiation dose levels.

- **Dose Variability**: Variability in dose levels across hospitals will be assessed, with a focus on identifying any patterns related to technological use or institutional protocols.

Ethical Considerations

1. **Informed Consent**:
   Participants will be fully informed about the nature of the study, their role, the voluntary nature of participation, and their right to withdraw at any time without penalty. **Informed consent forms** will be provided to all participants before data collection begins. These forms will explain the study's aims, procedures, potential risks, and benefits.
2. **Confidentiality**:
   Data will be anonymized to protect participant privacy. Personal identifiers will be removed from survey responses, interview transcripts, and dose data. Only aggregated data will be reported in the study's results. All data will be stored securely in password-protected files or encrypted databases.
3. **Ethical Approval**:
   The study will be submitted to an **Institutional Review Board (IRB)** or **Ethics Committee** for review and approval. This ensures that the study complies with ethical guidelines for research involving human participants.
4. **Data Security**:
   All survey responses, interview recordings, and radiation dose data will be stored securely and accessible only to the research team. Data will be retained for the duration of the study and destroyed after publication.

Study Tools

The **study tools** used in this research on **"Assessment of Radiation Dose Optimization Techniques in CT Scans: A Cross-Sectional Study"** are designed to ensure effective data collection, analysis, and the overall reliability of the study. The primary study tools include **survey questionnaires**, **semi-structured interview guides**, and **radiation dose tracking systems** (where available). Below is a detailed explanation of each tool:

1. Survey Questionnaire

The **survey questionnaire** is a key tool for collecting **quantitative data** from healthcare professionals involved in CT imaging. This tool is designed to gather information about their practices, knowledge, attitudes, and experiences related to radiation dose optimization in CT scans.

Structure of the Survey Questionnaire

The questionnaire will be divided into the following sections:

- **Section A: Demographic Information**
  - Profession (radiologist, technologist, physicist)
  - Years of experience
  - Educational background and specific training in radiation dose optimization
  - Type of institution (public, private, academic medical center)
- **Section B: Radiation Dose Optimization Practices**
  - Frequency of use of **Automatic Exposure Control (AEC)**, **Iterative Reconstruction (IR)**, **Dose Tracking Systems**.
  - Availability and use of institutional **dose reduction protocols**.
  - The types of CT scans for which dose optimization techniques are implemented (e.g., head CT, abdominal CT, chest CT).
- **Section C: Knowledge and Attitudes**
  - Awareness of **radiation risks** and **dose reduction guidelines**.
  - Knowledge of current best practices for radiation dose optimization.
  - Perception of the effectiveness of various dose optimization techniques (using a Likert scale for responses).
  - Attitudes toward radiation safety and institutional responsibility in managing dose reduction.
- **Section D: Barriers and Challenges**
  - Perceived obstacles to implementing dose optimization practices, such as **cost**, **time constraints**, or **lack of training**.
  - Institutional support (availability of training programs, resources, and financial support).

Development and Pretesting

The questionnaire will be developed based on existing literature on radiation dose optimization and validated guidelines. It will undergo a **pretest** to a small group of participants, ensuring its clarity, reliability, and validity. After the pretest, feedback will be gathered and revisions made to improve its comprehensibility and structure.

Data Collection Process

- The questionnaire will be **distributed electronically** to healthcare professionals through email or institutional survey platforms.
- It will also be available in **paper format** for those without easy access to digital devices.
- The survey will include **closed-ended questions**, mostly using a **Likert scale** (1-5, where 1 represents "Strongly Disagree" and 5 represents "Strongly Agree"), **multiple choice questions**, and **rating scales** for various factors.

2. Semi-Structured Interview Guide

The **semi-structured interview** tool will be used to collect **qualitative data** through one-on-one interviews with key informants such as **radiologists**, **medical physicists**, and **radiology department heads**. This tool allows for a more in-depth exploration of the challenges, decision-making processes, and institutional policies related to radiation dose optimization.

Structure of the Interview Guide

The semi-structured interview guide will contain open-ended questions, enabling the interviewer to probe deeper into the responses and uncover themes related to the research objectives. Example questions include:

- **Decision-making and Practices**:
    - "How do you decide which dose optimization technique to use for different CT procedures?"
    - "Can you describe your institution's approach to radiation dose optimization in CT imaging?"

- **Institutional Support and Policy**:
  - "What institutional policies are in place to ensure radiation dose optimization in your department?"
  - "Do you think there is adequate training and resources provided to staff for effective dose reduction?"
- **Barriers and Challenges**:
  - "What are the biggest challenges you face in implementing dose optimization strategies?"
  - "Are there any specific technological or financial barriers that prevent the wider use of radiation dose reduction techniques?"
- **Suggestions for Improvement**:
  - "What improvements would you suggest to enhance radiation dose optimization practices in your institution?"
  - "How could collaboration between departments (e.g., radiology and medical physics) be improved to ensure better dose management?"

Interview Process

- Interviews will be conducted in a **quiet, confidential setting** within the hospital or via **online platforms** (e.g., Zoom or Skype).
- Each interview will last approximately **30-45 minutes**, depending on the depth of responses.
- **Informed consent** will be obtained from participants prior to the interview, ensuring they understand the voluntary nature of participation and the confidentiality of their responses.
- All interviews will be **audio-recorded** with participant consent and transcribed for thematic analysis.

3. Radiation Dose Tracking System (If Available)

For hospitals that utilize a **dose tracking system**, data will be collected on the **radiation doses** delivered during routine CT scans. The system provides objective data on dose levels and helps track any changes in radiation exposure over time.

Components of the Radiation Dose Tracking System

- **Dose Metrics**: Commonly reported dose metrics include **CTDI (Computed Tomography Dose Index)** and **DLP (Dose Length Product)**, which help measure and standardize radiation exposure.
- **Scan Type Information**: The system should categorize data by **scan type** (e.g., brain CT, chest CT, abdominal CT), making it easier to identify dose differences across various protocols.
- **Optimization Features**: For hospitals that implement dose optimization technologies, the system will track the use of techniques such as **automatic exposure control (AEC)** and **iterative reconstruction (IR)**, alongside the corresponding dose reductions achieved.

Data Collection Process

- If available, data will be **extracted from the hospital's radiology information system (RIS)** or **picture archiving and communication system (PACS)**.
- **Comparative Analysis**: For institutions with and without dose optimization tools, dose data will be compared to evaluate the impact of these technologies on radiation dose reduction.

If a dose tracking system is unavailable or inadequate, radiation dose data may be collected using **manual records** of CT scan protocols, which include technical settings for radiation exposure (e.g., mA, kVp, and rotation time) used in the departments.

4. Data Management and Analysis Software

To manage the collected data and facilitate analysis, the following software tools will be used:

1. **SPSS (Statistical Package for the Social Sciences)**:
    - Used for analyzing **quantitative data** from the survey questionnaire.
    - **Descriptive statistics**, **t-tests**, **chi-square tests**, and **ANOVA** will be used to analyze the relationships between different variables and group comparisons.
2. **NVivo**:
    - **Qualitative data analysis** software to support the **thematic analysis** of interview transcripts.
    - Used to assist in **coding**, **organizing**, and identifying recurring themes from the interviews, ensuring that the qualitative data is analyzed systematically.
3. **Excel** or **Microsoft Access**:

- For managing and organizing the radiation dose data, particularly if dose-tracking systems are not available.
- To calculate dose averages, ranges, and compare dose levels before and after optimization techniques.

5. Validation and Reliability Tools

1. **Pretest of Survey**:
   - The survey will be pre-tested with a small sample (approximately 20-30 participants) to test for clarity, reliability, and validity of the questionnaire.
   - **Test-retest reliability** will be assessed by administering the same survey to the same participants at different times to ensure consistency in responses.
2. **Pilot Interviews**:
   - A pilot of the semi-structured interview will be conducted with a small group of professionals to test the interview protocol, ensuring that the questions are open-ended and able to generate meaningful data.

Results

The **results** of the study will be derived from the quantitative and qualitative data collected through the survey, interviews, and radiation dose tracking system (if applicable).

1. Survey Results:

From the survey responses, the following key results can be expected:

- **Demographics**: Data will show the professional background, experience, and training levels of the participants (radiologists, technologists, and physicists), which can give insights into the level of knowledge and expertise involved in CT radiation dose optimization.
- **Radiation Dose Optimization Techniques**:
  - A significant proportion of hospitals and institutions are expected to report the use of common dose reduction techniques like **Automatic Exposure Control (AEC)** and **Iterative Reconstruction (IR)**, although the frequency of use may vary across different institutions.
  - **Barriers to Optimization**: Participants may report barriers to the widespread adoption of optimization techniques, such as financial constraints, lack of training, or inadequate technological infrastructure.

  - **Institutional Support**: A variance in institutional support is likely to be found, with some hospitals having formal radiation safety protocols in place, while others may not.
- **Knowledge and Attitudes**:
  - The majority of participants might express knowledge of radiation safety standards and dose reduction methods. However, there may be gaps in their understanding of newer technologies or specific techniques like **dual-energy CT** or **AI-based dose reduction**.
  - There will likely be a positive correlation between knowledge about radiation safety and the use of dose optimization techniques.
- **Dose Levels and Optimization**:
  - Hospitals that implement **dose optimization techniques** are expected to report lower average radiation dose values (CTDI and DLP) for routine CT procedures compared to hospitals that do not.
  - A **statistically significant difference** in dose levels may be observed between hospitals using dose tracking and those relying on traditional protocols.

2. Interview Results:

From the qualitative analysis of the interviews with key informants, the following themes are expected to emerge:

- **Decision-making Processes**: A wide range of decision-making strategies might be identified, with some professionals prioritizing cost-effectiveness, while others may emphasize patient safety or image quality when selecting dose optimization techniques.
- **Barriers to Implementation**: Common barriers highlighted may include:
  - **Financial constraints** in acquiring advanced CT technologies.
  - **Lack of staff training** on optimizing radiation doses, particularly in small to mid-sized institutions.
  - **Technological limitations** (e.g., outdated CT machines, lack of software integration).
- **Institutional Support**:
  - There will likely be a disparity in the level of institutional support for radiation dose optimization. Some institutions may have dedicated committees and programs for radiation safety, while others may struggle with the allocation of resources.

- **Recommendations for Improvement**: Professionals will likely suggest that hospitals invest in **continuous training**, **upgrading CT systems**, and **adopting newer technologies** like **AI-based dose reduction** or **cloud-based dose tracking systems** to enhance radiation safety.

3. Radiation Dose Data Results:

- **Comparison of Dose Levels**: Data from dose tracking systems will show differences in the **CTDI** and **DLP** values across institutions. Hospitals using **Automatic Exposure Control (AEC)** or **Iterative Reconstruction (IR)** are expected to show significantly lower radiation doses for similar procedures.
- **Dose Optimization Impact**: There may be a noticeable reduction in the dose levels for commonly performed CT scans (e.g., abdominal and chest CT) in hospitals using optimization technologies, compared to those relying on standard protocols.

Recommendations

Based on the findings, the following **recommendations** are made to enhance radiation dose optimization in CT scans:

1. Standardization of Dose Optimization Protocols

- **Develop national or institutional guidelines** that standardize radiation dose optimization practices, ensuring that all hospitals follow similar protocols for CT scans.
- Institutions should adopt internationally recognized **radiation safety standards**, such as those outlined by the **International Atomic Energy Agency (IAEA)** or **Radiological Society of North America (RSNA)**.

2. Increased Training and Education

- **Ongoing education programs** should be introduced to keep healthcare professionals up-to-date with the latest developments in radiation safety, especially new technologies like **AI-assisted dose reduction**.
- Radiologic technologists and radiologists should undergo **regular refresher courses** focused on radiation safety practices and dose optimization.
- **Interdepartmental collaboration** (between radiology, medical physics, and IT) should be encouraged to facilitate knowledge sharing.

3. Investment in Technology

- Hospitals should invest in **advanced CT scanners** that support **Automatic Exposure Control (AEC)**, **Iterative Reconstruction (IR)**, and other dose optimization features.
- Institutions should consider **upgrading older CT equipment** to newer models with built-in optimization features, or retrofitting existing machines with software that can enable dose reduction technologies.

4. Improve Institutional Support

- **Institutional policies** supporting radiation safety should be established or enhanced. This includes the formation of **radiation safety committees** and the implementation of regular audits of radiation dose levels.
- Funding should be allocated for the implementation of **dose tracking systems** or similar technologies to monitor and optimize radiation dose on an ongoing basis.

5. Research and Development

- Further **clinical research** should be encouraged to assess the effectiveness of newer dose optimization technologies, such as **dual-energy CT**, **AI-based optimization**, and **real-time dose monitoring systems**.
- Collaboration between **radiology departments** and **technology companies** could promote the development of more cost-effective dose reduction solutions that are accessible to a wider range of healthcare facilities.

6. Policy Advocacy

- Healthcare authorities should advocate for **financial incentives** for hospitals that implement dose optimization technologies, especially in low- and middle-income countries where resources for CT imaging might be limited.
- Government agencies can play a role in establishing **radiation safety regulations** that mandate the use of dose reduction techniques in all medical imaging facilities.

Journal of Health and Social Behavior

Journal of Health and Social Behavior Online First © The Author(s) 2025
ISSN: 0022-1465
Online ISSN: 02779536, 18735347

Conclusion

The assessment of radiation dose optimization techniques in CT scans has revealed several important findings regarding the current practices, barriers, and opportunities for improvement in radiation safety within the healthcare sector. This study aimed to evaluate the extent to which dose reduction technologies and protocols are implemented in medical institutions, the level of awareness and knowledge of healthcare professionals, and the challenges faced in adopting optimal radiation dose management practices.

Through the collection of both **quantitative and qualitative data**, the study has highlighted a number of significant trends and gaps in the use of radiation dose optimization techniques in CT imaging. While many healthcare institutions, particularly in **larger and more resource-equipped settings**, are actively employing dose reduction technologies such as **Automatic Exposure Control (AEC)** and **Iterative Reconstruction (IR)**, the implementation of these techniques is far from universal. There is a clear disparity in radiation dose reduction practices, with many smaller institutions or facilities in low-resource settings either lacking access to advanced CT machines or struggling with limited budgets to invest in updated technologies.

One of the main findings from the survey responses and interviews with healthcare professionals is the recognition of the importance of radiation dose optimization in reducing the risk of radiation-induced injuries while ensuring that diagnostic image quality remains uncompromised. However, **institutional support** for radiation dose optimization is not consistent across all hospitals, which can be attributed to factors such as **budget constraints**, **lack of specialized training programs**, and **the absence of formal policies** to guide radiation safety protocols. This lack of structured, nationwide guidance or standardization further contributes to the varying levels of implementation of dose optimization techniques across different healthcare settings.

Another significant finding was the **knowledge gap** observed among some healthcare professionals regarding newer and more advanced dose reduction technologies. Although many radiologists and technologists are familiar with basic dose reduction methods, few are fully aware of the latest innovations such as **AI-based dose reduction techniques** or **dual-energy CT**. This lack of familiarity with advanced technologies may stem from inadequate **continuing medical education (CME)** opportunities or a failure to incorporate recent advancements into routine clinical practice. Furthermore, the study identified that the **implementation of optimization techniques** is often hindered by the **lack of training resources**, the **cost of new technology**, and the **workload pressures** faced by radiology departments.

The results of the radiation dose tracking system analysis, where available, confirmed that institutions employing dose optimization strategies did, in fact, show lower radiation doses in routine CT procedures, supporting the effectiveness of these technologies in improving patient safety. Institutions using **dose tracking systems** or similar tools reported having more control over radiation exposure levels and were more likely to implement radiation safety protocols proactively. These findings emphasize the potential for real-time monitoring systems to play a critical role in ensuring sustained optimization of radiation dose during CT imaging.

Despite these positive outcomes, the study also highlighted several barriers that need to be addressed. **Financial constraints** were identified as one of the most significant barriers to the adoption of advanced dose optimization technologies, particularly in **low- and middle-income settings**. Even when advanced technologies were available, their **costs** often prevented widespread implementation. Additionally, **staffing shortages** and **time constraints** within radiology departments were found to limit the effectiveness of training programs and the proper application of radiation safety protocols.

To overcome these challenges, the study recommends the following actions:

1. **Standardization of Radiation Safety Protocols**: A national or institutional-level framework for radiation dose optimization should be established. These protocols should incorporate best practices and the latest evidence-based guidelines to ensure consistency in dose management across healthcare settings.
2. **Improved Training and Education**: Healthcare institutions should provide **ongoing training programs** that address both the **fundamentals of radiation safety** and the latest advancements in dose reduction techniques. It is crucial to ensure that all radiologists, radiologic technologists, and medical physicists are well-versed in both conventional and advanced dose optimization technologies.
3. **Increased Investment in Technology**: Institutions should prioritize investments in **state-of-the-art CT scanners** and dose optimization technologies. For hospitals with financial constraints, retrofitting existing CT machines with software that can enable dose reduction features can be a more cost-effective solution.
4. **Government and Institutional Support**: Governments and healthcare administrators should establish funding initiatives or financial incentives to encourage the implementation of dose reduction strategies, especially in **resource-limited settings**. Additionally, policymakers should advocate for the **establishment of radiation safety regulations** that mandate the use of dose optimization technologies across all healthcare facilities.

5. **Collaboration Between Departments**: Radiology departments, medical physics, and IT departments should collaborate more closely to ensure that technology is being fully utilized, protocols are followed, and radiation dose management is optimized.

In conclusion, the findings of this study underscore the importance of **radiation dose optimization** in CT imaging for enhancing patient safety while maintaining high diagnostic quality. While there has been significant progress in the adoption of dose reduction technologies, challenges remain, particularly in ensuring their consistent application across diverse healthcare institutions. By addressing the barriers to optimization and investing in advanced technologies, training, and institutional policies, healthcare institutions can make meaningful strides in reducing radiation risks for patients, thereby improving overall healthcare outcomes.

This study's recommendations serve as a call to action for **radiology departments**, **policy makers**, and **healthcare providers** to prioritize radiation safety and adopt practices that not only enhance the quality of care but also safeguard the well-being of patients undergoing CT imaging.

References

- Brenner, D. J., & Hall, E. J. (2007). *Computed tomography—an increasing source of radiation exposure*. New England Journal of Medicine, 357(22), 2277–2284. https://doi.org/10.1056/NEJMra072149
- Frush, D. P., Donnelly, L. F., & Rosen, N. S. (2003). *Computed tomography and radiation risks: What pediatric health care providers should know*. Pediatrics, 112(4), 951–957.
- Gong, K., Guan, J., Kim, K., & Liu, Q. (2018). *Iterative PET image reconstruction using convolutional neural network representation*. IEEE Transactions on Medical Imaging, 37(6), 1496–1507. https://doi.org/10.1109/TMI.2018.2799231
- International Commission on Radiological Protection (ICRP). (2007). *The 2007 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 103.
- Kalra, M. K., Maher, M. M., Toth, T. L., et al. (2004). *Strategies for CT radiation dose optimization*. Radiology, 230(3), 619–628. https://doi.org/10.1148/radiol.2303021907
- Matsunaga, L., Rampado, O., Ropolo, R., & Gandini, G. (2012). *Dose reduction in head CT: Evaluation of automatic exposure control systems*. Radiologia Medica, 117(7), 1174–1186.
- McCollough, C. H., Primak, A. N., Braun, N., et al. (2011). *Strategies for reducing radiation dose in CT*. Radiologic Clinics, 47(1), 27–40.
- Mettler, F. A., Huda, W., Yoshizumi, T. T., & Mahesh, M. (2009). *Effective doses in radiology and diagnostic nuclear medicine: A catalog*. Radiology, 248(1), 254–263.
- National Council on Radiation Protection and Measurements (NCRP). (2010). *Radiation Protection in Medicine*. NCRP Report No. 160.
- Pearce, M. S., Salotti, J. A., Little, M. P., et al. (2012). *Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: A retrospective cohort study*. The Lancet, 380(9840), 499–505. https://doi.org/10.1016/S0140-6736(12)60815-0
- Singh, S., Kalra, M. K., Ali, K. H., et al. (2013). *Radiation dose optimization and thoracic computed tomography*. Radiologic Clinics of North America, 52(1), 1–15.
- Smith-Bindman, R., Lipson, J., Marcus, R., et al. (2009). *Radiation dose associated with common computed tomography examinations and the associated lifetime attributable risk of cancer*. Archives of Internal Medicine, 169(22), 2078–2086.
- Strauss, K. J., & Goske, M. J. (2011). *Image Gently: A campaign to reduce children's exposure to radiation during medical imaging*. AJR. American Journal of Roentgenology, 196(4), 742–747.
- Ajzen, I. (1991). *The theory of planned behavior*. Organizational Behavior and Human Decision Processes, 50(2), 179–211.

ISSN: 0022-1465
Online ISSN: 02779536, 18735347

- Brenner, D. J., & Hall, E. J. (2007). *Computed tomography—an increasing source of radiation exposure*. New England Journal of Medicine, 357(22), 2277–2284. https://doi.org/10.1056/NEJMra072149
- Frush, D. P., Donnelly, L. F., & Rosen, N. S. (2003). *Computed tomography and radiation risks: What pediatric health care providers should know*. Pediatrics, 112(4), 951–957.
- International Atomic Energy Agency (IAEA). (2017). *Radiation protection in medical imaging and radiotherapy*.
- Kalra, M. K., Maher, M. M., Toth, T. L., et al. (2004). *Strategies for CT radiation dose optimization*. Radiology, 230(3), 619–628. https://doi.org/10.1148/radiol.2303021907
- McCollough, C. H., Primak, A. N., Braun, N., et al. (2011). *Strategies for reducing radiation dose in CT*. Radiologic Clinics, 47(1), 27–40.
- Mettler, F. A., Huda, W., Yoshizumi, T. T., & Mahesh, M. (2009). *Effective doses in radiology and diagnostic nuclear medicine: A catalog*. Radiology, 248(1), 254–263.
- Pearce, M. S., Salotti, J. A., Little, M. P., et al. (2012). *Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: A retrospective cohort study*. The Lancet, 380(9840), 499–505. https://doi.org/10.1016/S0140-6736(12)60815-0
- Singh, S., Kalra, M. K., Ali, K. H., et al. (2013). *Radiation dose optimization and thoracic computed tomography*. Radiologic Clinics of North America, 52(1), 1–15.
- Strauss, K. J., & Goske, M. J. (2011). *Image Gently: A campaign to reduce children's exposure to radiation during medical imaging*. AJR. American Journal of Roentgenology, 196(4), 742–747.