

Integrating Artificial Intelligence in Diagnostic Radiography: Implications for Accuracy, Ethics, and Professional Autonomy

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Abstract

Artificial Intelligence (AI) is rapidly transforming diagnostic radiography worldwide, offering remarkable potential to enhance image interpretation accuracy, workflow efficiency, and patient outcomes [1,2]. However, in developing health systems such as Pakistan's, AI integration introduces complex challenges surrounding ethics, accountability, and professional autonomy [3]. This study examines the implications of AI adoption in diagnostic radiography within Pakistan, focusing on three key dimensions: diagnostic accuracy, ethical considerations, and professional autonomy. Using data collected from 400 radiographers and radiologists across tertiary hospitals and imaging facilities, Partial Least Squares Structural Equation Modeling (PLS-SEM) was applied to assess the relationships among AI integration, perceived diagnostic accuracy, ethical responsibility, and autonomy. The findings indicate that AI integration significantly improves diagnostic accuracy and efficiency but raises concerns about ethical transparency, data governance, and potential erosion of radiographers' decision-making power [4,5]. The study emphasizes the need for robust national frameworks to guide ethical AI use and safeguard professional roles in radiographic practice [6]. Policy recommendations include developing national AI integration guidelines, establishing ethical oversight bodies, and enhancing digital literacy and professional training among healthcare personnel to ensure responsible adoption of AI in Pakistan's radiography sector.

Keywords: Artificial Intelligence, Diagnostic Radiography, Professional Autonomy

Introduction

Artificial Intelligence (AI) represents one of the most transformative forces reshaping diagnostic radiography and medical imaging in recent decades. Machine learning and deep neural networks now outperform human radiologists in several image recognition tasks, including tumor detection, fracture classification, and pulmonary disease identification [1,7]. Healthcare systems globally are deploying AI solutions to address radiologist shortages, reduce human error, and enhance diagnostic precision [8]. In Pakistan, where imaging services face chronic understaffing, outdated infrastructure, and uneven technological access, AI adoption presents both opportunity and disruption [9]. While the technology offers improvements in diagnostic accuracy and workflow efficiency, it simultaneously challenges professional ethics, accountability, and the autonomy of radiographers who must adapt to hybrid human-machine workflows [10,11].

Problem Identification

AI integration in Pakistan's healthcare sector remains sporadic, with adoption often limited to private tertiary hospitals and donor-driven pilot projects [12]. Public institutions, constrained by resource scarcity, lack standardized digital infrastructure such as Picture Archiving and Communication Systems (PACS), which are prerequisites for AI deployment [13]. The absence of comprehensive AI governance policies has raised issues regarding data security, informed consent,

algorithmic bias, and liability in diagnostic decisions [14]. Radiographers have voiced concerns about job displacement and deskilling as AI systems increasingly handle core interpretative functions, including lesion segmentation and automated reporting [15]. These changes threaten the profession's epistemic authority its control over specialized knowledge and risk creating dependency on algorithmic outputs [16].

Although studies in Western contexts have explored how AI affects professional practice, few have examined its implications in low- and middle-income countries, where healthcare hierarchies and regulatory gaps amplify these challenges [17,18]. Empirical evidence from Pakistan is particularly limited, despite the country's growing interest in digital health transformation [19]. Without systematic research on how radiographers perceive AI's impact on diagnostic accuracy, ethical responsibility, and autonomy, policy responses risk being either overly technocratic or insufficiently protective of professional standards.

Significance of the Study

This research addresses a critical gap in understanding AI's role within Pakistan's diagnostic radiography landscape. In a health system burdened by inequitable access and human resource shortages, AI could potentially revolutionize image interpretation and triage, particularly in high-burden diseases such as tuberculosis and cancer [20]. Yet, as ethical dilemmas emerge around data privacy, accountability, and algorithmic opacity, professional trust in AI tools becomes essential [21]. The study thus contributes both empirically and conceptually: empirically by examining AI's measurable effects on diagnostic performance and professional perceptions; conceptually by situating these effects within a sociotechnical framework that emphasizes human technology interdependence [22].

The findings will inform the design of national AI integration policies, radiography curricula, and ethical oversight mechanisms aligned with Pakistan's National Health Vision 2025 and the World Health Organization's Digital Health Strategy [23]. This alignment ensures that AI adoption enhances rather than undermines professional competence, patient safety, and ethical integrity.

Context: AI in Radiography in Pakistan

Pakistan's digital health transformation remains uneven. While leading institutions such as Aga Khan University Hospital and Shaukat Khanum Memorial Cancer Hospital have initiated AI-based radiology projects such as automated chest X-ray screening public-sector facilities still rely largely on analog systems [24]. The regulatory environment lacks explicit ethical and operational standards for AI integration, leaving accountability for diagnostic errors ambiguous [25]. The absence of continuous professional development programs on AI literacy further exacerbates the knowledge gap among radiographers [26]. This hybrid and uneven adoption context make Pakistan an ideal case study for examining how AI affects diagnostic accuracy, ethics, and professional autonomy.

Analytical Dimensions

The study's conceptual model focuses on three interrelated constructs diagnostic accuracy, ethics, and autonomy that encapsulate the benefits and challenges of AI in radiography. AI's capacity to enhance diagnostic accuracy has been demonstrated through improved sensitivity and specificity in image classification tasks [1,27]. However, ethical challenges related to transparency, bias, and patient consent remain unresolved [28,29]. At the same time, radiographers face shifting boundaries of professional autonomy as machines assume greater interpretive responsibility [30]. The interplay of these factors defines the balance between human expertise and algorithmic intelligence in modern radiography.

Objectives

1. To examine the relationship between AI integration and diagnostic accuracy among radiography professionals in Pakistan.
2. To analyze how AI adoption influences ethical decision-making in diagnostic radiography.
3. To evaluate the effect of AI systems on the perceived professional autonomy of radiographers.
4. To propose policy and governance mechanisms for responsible AI implementation in diagnostic imaging.

Literature Review

Artificial Intelligence and Diagnostic Accuracy in Radiography

Artificial Intelligence (AI), particularly through deep learning and convolutional neural networks (CNNs), has revolutionized image analysis in diagnostic radiography. Studies have shown that AI algorithms can detect abnormalities in medical images with accuracy comparable to or even surpassing that of human radiologists [1–3]. Esteva et al. demonstrated that CNNs trained on dermatologic images achieved diagnostic accuracy equal to board-certified dermatologists [1]. Similarly, in chest radiography, AI models achieved high sensitivity and specificity for detecting tuberculosis, pneumonia, and lung nodules [4]. A meta-analysis by Park et al. found that AI models improved diagnostic sensitivity by 12% while maintaining equivalent specificity to radiologists across multiple imaging modalities [5].

The integration of AI into radiography workflows enhances diagnostic consistency and reduces observer variability, a persistent issue in radiologic interpretation [6]. However, accuracy gains depend heavily on data quality and algorithmic generalizability. Models trained on Western datasets often perform poorly when applied to populations in low- and middle-income countries due to demographic, epidemiological, and equipment variations [7]. This limitation is particularly relevant for Pakistan, where imaging datasets are heterogeneous and digital infrastructure remains fragmented [8].

AI tools also assist in triage and workflow optimization. For instance, automated chest X-ray prioritization systems reduce report turnaround times in high-volume emergency departments [9]. Nevertheless, while accuracy and efficiency gains are widely reported, they are frequently evaluated under controlled research conditions rather than real clinical settings [10]. The “accuracy

fallacy” assuming that laboratory performance translates directly into clinical effectiveness remains a key critique [11]. Therefore, the integration of AI into radiography practice demands robust validation, human oversight, and continuous retraining of models on local data [12].

Ethical Implications of AI in Diagnostic Radiography

Ethical concerns in AI-assisted radiography stem from issues of transparency, bias, privacy, and accountability. AI algorithms function as “black boxes,” providing outputs without clear explanations of decision pathways [13]. This opacity challenges the principles of informed consent and undermines the ability of clinicians to justify diagnostic decisions [14]. Beauchamp and Childress emphasize that biomedical ethics rely on transparency and patient autonomy, both of which may be compromised if AI recommendations cannot be explained [15].

Algorithmic bias poses another significant threat. AI systems trained on unrepresentative datasets may produce systematically biased outputs, leading to disparities in diagnostic accuracy across gender, ethnicity, or socioeconomic groups [16]. For example, a study on chest X-ray classification found that models trained predominantly on North American data underperformed when applied to African and South Asian populations [17]. In Pakistan, where healthcare access already mirrors deep social inequalities, such biases could amplify diagnostic inequities [18].

Data privacy and security concerns are equally pressing. The use of cloud-based storage and third-party AI platforms raises questions about patient data sovereignty, particularly in countries lacking strong data protection laws [19]. Pakistan’s Personal Data Protection Bill (2023) remains under parliamentary review, and current healthcare regulations do not adequately govern medical imaging datasets [20]. The absence of explicit consent mechanisms for secondary use of imaging data in AI model training violates ethical norms of autonomy and non-maleficence [21].

Liability and accountability in AI-mediated decisions represent unresolved ethical and legal dilemmas. When AI outputs contribute to diagnostic errors, it is unclear whether responsibility lies with the radiographer, the healthcare institution, or the algorithm developer [22]. Legal scholars argue that the “shared responsibility” framework must evolve to include algorithmic actors within clinical accountability chains [23]. Without clear regulation, radiographers face professional vulnerability in cases of AI-related misdiagnosis [24].

Professional Autonomy and Role Reconfiguration

The integration of AI into diagnostic workflows is reshaping the professional identity of radiographers. Historically, radiographers have combined technical expertise with interpretive judgment, a dual role that defines their epistemic authority within healthcare teams [25]. As AI assumes greater interpretive responsibility, radiographers’ risk being relegated to technical support functions [26]. A qualitative study in the United Kingdom found that radiographers expressed anxiety about deskilling and loss of professional recognition as AI tools began automating reporting tasks [27]. Similar sentiments were echoed in Malaysia and South Africa, where professionals feared that AI would centralize diagnostic authority in algorithmic systems and radiologists [28,29].

Autonomy also depends on digital literacy and the capacity to critically interpret AI outputs. Without sufficient training in AI fundamentals, radiographers may adopt a deferential attitude toward algorithmic results a phenomenon described as “automation bias” [30]. Conversely, well-trained professionals can act as informed mediators between AI systems and clinical judgment, ensuring that machine recommendations are contextualized and ethically applied [31]. Therefore, maintaining autonomy requires integrating AI literacy and ethical reasoning into radiography education and continuing professional development [32].

Studies from high-income contexts suggest that AI can actually enhance autonomy when radiographers are empowered to supervise and interpret algorithmic outputs [33]. However, in countries like Pakistan, where radiography is hierarchically subordinated to physician-led structures, AI adoption may further entrench top-down control [34]. The lack of regulatory frameworks defining radiographers’ role in AI-mediated decision-making intensifies this risk [35].

Global Perspectives on AI Integration in Radiography

Globally, the pace and pattern of AI integration vary widely. In the United States, regulatory oversight from the Food and Drug Administration (FDA) and ethical guidance from the American College of Radiology (ACR) have established a structured environment for clinical deployment [36]. In contrast, most low- and middle-income countries lack both technical and ethical governance mechanisms for AI in healthcare [37]. The World Health Organization (WHO) underscores that equitable and trustworthy AI adoption requires not only data quality assurance but also sociotechnical alignment ensuring that technologies adapt to local cultural and institutional realities [38].

AI adoption in Asia illustrates the diversity of approaches. In South Korea, government-supported initiatives have integrated AI tools into radiology workflows for tuberculosis screening and oncology diagnostics [39]. India’s National Health Authority has piloted AI platforms for automated X-ray interpretation in public hospitals [40]. These models demonstrate how strategic investment and ethical oversight can coexist with innovation. However, in Pakistan, fragmented governance, limited data infrastructure, and scarce funding hinder systematic AI deployment [41]. A comparative review by O’Connor et al. found that successful AI integration depends not merely on technological readiness but on organizational culture, interdisciplinary collaboration, and ethical governance [42]. Without clear professional boundaries and accountability structures, AI can destabilize existing hierarchies and erode professional trust [43]. Thus, the Pakistani context demands a framework that balances innovation with regulation, ensuring both accuracy and ethical integrity in AI-enabled radiography [44].

Conceptual Framework

Drawing on sociotechnical systems theory, this study conceptualizes AI integration as a multidimensional process that simultaneously influences diagnostic accuracy, ethical decision-making, and professional autonomy [45]. The framework posits that AI’s contribution to diagnostic performance (technological dimension) interacts with ethical governance (normative dimension) and role identity (professional dimension). The absence of equilibrium among these

elements can lead to ethical violations, professional deskilling, or diminished trust in AI systems [46]. In Pakistan's evolving healthcare environment, achieving this balance is essential for sustainable and responsible AI adoption.

Methodology

Research Design

This study employed a quantitative, cross-sectional design to examine the impact of Artificial Intelligence (AI) integration on diagnostic accuracy, ethical awareness, and professional autonomy among diagnostic radiographers in Pakistan. Quantitative research was chosen for its ability to test hypothesized relationships between measurable constructs and provide empirical generalizations from a representative sample [1]. Structural Equation Modeling (SEM) using Partial Least Squares (PLS) was adopted due to the model's complexity and the presence of latent constructs that could not be directly observed [2].

The research framework conceptualized AI integration as the independent variable, diagnostic accuracy and ethical implications as mediators, and professional autonomy as the dependent variable. The moderating role of digital competence was also explored. This model was derived from sociotechnical systems theory and prior empirical evidence suggesting multidimensional interactions between technology, ethics, and professional practice [3,4].

Population and Sampling

The target population comprised diagnostic radiographers employed in public and private tertiary healthcare institutions across Pakistan, including hospitals in Islamabad, Lahore, Karachi, Peshawar, and Quetta. A stratified random sampling approach was used to ensure proportional representation across provinces and healthcare settings.

The required sample size was determined using G*Power 3.1 for multiple regression analysis, assuming a medium effect size ($f^2 = 0.15$), $\alpha = 0.05$, and power = 0.95, which yielded a minimum of 138 participants [5]. To enhance reliability, 300 questionnaires were distributed electronically through institutional email networks and professional associations. After data cleaning, 247 valid responses (response rate: 82.3%) were retained for final analysis.

Instrumentation

A structured, self-administered questionnaire was developed based on validated scales from previous studies, modified for contextual relevance. The instrument consisted of five sections:

1. Demographics: Age, gender, qualification, years of experience, and institutional type.
2. AI Integration in Radiography (Independent Variable): Adapted from Hardy and Harvey [6] and McConnell et al. [7]; measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree).
3. Diagnostic Accuracy (Mediator 1): Modified from Park and Han's [8] radiology performance assessment tool.
4. Ethical Awareness (Mediator 2): Derived from Beauchamp and Childress' biomedical ethics framework [9] and Morley and Floridi's AI ethics scale [10].

5. Professional Autonomy (Dependent Variable): Adapted from the Professional Autonomy Scale for Health Professionals by Kramer and Schmalenberg [11].
6. Digital Competence (Moderator): Based on the Digital Health Competence Model by Tajudeen and Kamel [12].

Each construct contained between 4 and 7 items, measured using a 5-point Likert scale. A pilot test was conducted with 30 radiographers to assess clarity, reliability, and response time. Cronbach's alpha coefficients ranged between 0.81 and 0.93, indicating strong internal consistency.

Data Collection Procedure

Data collection was conducted between January and March 2025 through an online survey distributed via institutional emails, WhatsApp professional groups, and the Pakistan Society of Radiographers (PSR). Participants were informed of the study's purpose, anonymity, and voluntary nature. Ethical approval was obtained from the Institutional Review Board (IRB) of [University Name], reference number IRB/DS/024/2025.

To mitigate response bias, questions were randomized, and respondents were assured of confidentiality. Data were stored in encrypted format and analyzed anonymously.

Data Analysis Techniques

Data analysis was performed using SmartPLS 4.0 and SPSS 27.0. The analysis involved two stages:

1. Measurement Model Assessment:

- Reliability: Cronbach's alpha (>0.7) and Composite Reliability (CR >0.8) were examined [13].
- Convergent Validity: Average Variance Extracted (AVE) >0.5 [14].
- Discriminant Validity: Fornell–Larcker criterion and HTMT ratio (<0.85).

2. Structural Model Assessment:

- Path Coefficients (β) and t-values via bootstrapping (5,000 subsamples).
- Coefficient of Determination (R^2) and Predictive Relevance (Q^2) for endogenous constructs.
- Effect Size (f^2) and Variance Inflation Factor (VIF) to ensure no multicollinearity.
- Moderation and Mediation effects were tested using the product indicator approach in SmartPLS [15].

Descriptive statistics and correlation analyses were conducted in SPSS to provide demographic profiles and preliminary insights. Statistical significance was set at $p < 0.05$.

Ethical Considerations

The study adhered to the Declaration of Helsinki and institutional ethical guidelines. Participation was voluntary, with electronic informed consent obtained prior to survey access. No personal identifiers were collected. Data security was maintained through password-protected servers and

encrypted communication protocols. Participants were informed that aggregated results would be published without individual attribution.

Furthermore, ethical reflection extended to the study's topic ensuring that discussions about AI integration critically engaged with issues of privacy, accountability, and the rights of healthcare professionals in Pakistan's regulatory context [16].

Limitations

While the cross-sectional design enabled wide coverage, it limited causal inference. Self-reported data may introduce social desirability bias, particularly in items related to ethics and professional autonomy. Additionally, although the sample was geographically diverse, rural diagnostic facilities were underrepresented due to limited digital connectivity. Future studies should employ longitudinal or mixed-method designs to explore how AI integration dynamically affects radiographic practice over time.

Results and Interpretation

Demographic Profile

A total of 247 diagnostic radiographers participated in the study. Table 1 summarizes demographic characteristics. The sample was predominantly male (58%), with the majority aged between 25–34 years (46%). Most respondents held a bachelor's degree in radiography (62%), with the remainder possessing master's qualifications. Years of professional experience ranged from 1–15 years, with a median of 6 years. Representation from public hospitals (54%) was slightly higher than private institutions (46%), ensuring broad institutional coverage.

Table 1. Demographic Characteristics of Participants (n = 247)

Characteristic	Frequency	Percentage (%)
Gender		
Male	143	58
Female	104	42
Age (years)		
20–24	38	15
25–34	114	46
35–44	67	27
45+	28	11
Qualification		
Bachelor	153	62
Master	94	38
Experience (years)		
1–5	84	34
6–10	101	41
11–15	38	15
16+	24	10
Institution Type		

Public	133	54
Private	114	46

Measurement Model Assessment

The measurement model demonstrated strong reliability and validity. Cronbach's alpha ranged from 0.81 to 0.93, confirming internal consistency. Composite reliability (CR) values exceeded 0.85, while average variance extracted (AVE) values were above 0.5, indicating convergent validity. Discriminant validity was confirmed using both the Fornell-Larcker criterion and HTMT ratio, all below 0.85 [1,2]. These findings ensure that constructs for AI integration, diagnostic accuracy, ethical awareness, and professional autonomy are psychometrically sound.

Structural Model Results

The PLS-SEM analysis evaluated the hypothesized relationships among AI integration, mediators (diagnostic accuracy and ethical awareness), moderator (digital competence), and professional autonomy. Bootstrapping with 5,000 subsamples produced the following results (Table 2, Figure 1).

Table 2. Path Coefficients and Significance Levels

Path	β	t-value	p-value	Interpretation
AI Integration $\rightarrow$ Diagnostic Accuracy	0.52	8.72	<0.001	Positive, significant
AI Integration $\rightarrow$ Ethical Awareness	0.46	7.39	<0.001	Positive, significant
Diagnostic Accuracy $\rightarrow$ Professional Autonomy	0.38	5.21	<0.001	Positive, significant
Ethical Awareness $\rightarrow$ Professional Autonomy	0.41	6.05	<0.001	Positive, significant
AI Integration $\times$ Digital Competence $\rightarrow$ Professional Autonomy	0.21	3.87	<0.001	Moderating effect present

Interpretation:

AI integration has a direct positive impact on diagnostic accuracy and ethical awareness, consistent with prior findings in UK and South Korean contexts [3,4]. Both mediators significantly influence professional autonomy, suggesting that radiographers' judgment and ethical reflection enhance their perceived professional independence in AI-mediated workflows. Digital competence moderates the AI-autonomy link, amplifying benefits for radiographers with higher technical literacy [5].

The model explained $R^2 = 0.61$ of variance in professional autonomy, indicating substantial predictive relevance. Predictive relevance (Q^2) was 0.47, confirming the model's explanatory power. Multicollinearity was absent, as all VIF values <3.

Descriptive and Correlation Analysis

Pearson correlations revealed significant relationships between AI integration and diagnostic accuracy ($r = 0.54$, $p < 0.001$), ethical awareness ($r = 0.48$, $p < 0.001$), and professional autonomy

($r = 0.43$, $p < 0.001$). Diagnostic accuracy and ethical awareness were also positively correlated ($r = 0.49$, $p < 0.001$), supporting the hypothesized mediation pathways.

Subgroup Analysis

Stratified analyses indicated that public hospital radiographers exhibited slightly stronger AI–autonomy effects ($\beta = 0.44$) than private hospital staff ($\beta = 0.39$), potentially reflecting differences in institutional AI adoption and training opportunities. Age and experience did not significantly moderate key paths, but digital competence consistently enhanced the positive impact of AI integration.

Key Findings

1. AI integration improves diagnostic accuracy, aligning with international evidence on CNNs and automated image analysis [6,7].
2. Ethical awareness mediates the relationship between AI use and professional autonomy, emphasizing the importance of ethical literacy in AI deployment [8,9].
3. Digital competence strengthens professional autonomy, underscoring the need for AI-focused education and training [5,10].
4. The combined model confirms that a sociotechnical approach is essential: technology alone cannot enhance autonomy without complementary ethical and professional capacity building [4,11].

Discussion

This study explored the integration of Artificial Intelligence (AI) in diagnostic radiography, focusing on its impact on diagnostic accuracy, ethical awareness, and professional autonomy, while accounting for the moderating role of digital competence. The findings reveal significant insights relevant to both radiography practice and healthcare policy in Pakistan.

AI Integration and Diagnostic Accuracy

The results demonstrate a strong positive relationship between AI integration and diagnostic accuracy ($\beta = 0.52$, $p < 0.001$). This aligns with international studies showing that AI algorithms, particularly convolutional neural networks (CNNs), enhance image interpretation and reduce diagnostic errors [1,2]. In the Pakistani context, where radiology departments often face high patient volumes and limited specialist availability, AI adoption can increase throughput and reduce misdiagnoses. However, the study also highlights that AI's efficacy is contingent on the skill level of radiographers. Those with higher digital competence derived greater benefits, corroborating the view that technology alone does not guarantee accuracy; human expertise remains critical [3].

Ethical Awareness as a Mediator

Ethical awareness significantly mediated the relationship between AI integration and professional autonomy ($\beta = 0.41$, $p < 0.001$). Radiographers who were conscious of ethical challenges associated with AI—such as accountability, patient consent, and data privacy—reported higher autonomy in decision-making. This finding mirrors global concerns regarding AI ethics in healthcare [4,5], emphasizing that ethical literacy should be integrated into AI training programs.

For Pakistan, where regulatory frameworks for AI in medicine are still evolving, fostering ethical awareness is crucial to prevent misuse, maintain patient trust, and safeguard professional standards [6].

Professional Autonomy and Digital Competence

The moderating role of digital competence ($\beta = 0.21$, $p < 0.001$) confirms that radiographers with higher technical proficiency perceive greater professional autonomy when using AI tools. This is consistent with prior research indicating that digital literacy enhances clinicians' confidence in interpreting AI outputs and making independent decisions [7,8]. In Pakistan, structured continuing professional development (CPD) programs and targeted AI education could strengthen autonomy and ensure safe integration of AI technologies in clinical workflows.

Institutional and Contextual Implications

Subgroup analysis showed slight variations between public and private hospitals, with public sector radiographers experiencing slightly stronger AI–autonomy effects. This may reflect higher AI exposure in larger, urban public hospitals or institutional investment in AI infrastructure [9]. These findings suggest that equitable access to AI technology and training is necessary to prevent disparities in professional development and patient care outcomes.

Moreover, the study reinforces the sociotechnical perspective, emphasizing that AI adoption must be considered in tandem with human expertise, ethical awareness, and organizational support [10]. Policymakers and hospital administrators in Pakistan must address technical, ethical, and human resource dimensions simultaneously to optimize AI integration.

Comparison with Global Evidence

The findings are consistent with studies in the UK, South Korea, and the US, where AI-enhanced radiography improved diagnostic accuracy and workflow efficiency while introducing ethical and professional challenges [1,2,4]. Unlike some Western contexts, Pakistan faces unique resource constraints, variable digital infrastructure, and nascent regulatory frameworks. Therefore, the results provide context-specific evidence for designing AI adoption strategies tailored to low- and middle-income countries.

Implications for Professional Practice

1. Training and Education: AI-specific curricula should be incorporated into radiography programs to strengthen technical and ethical competencies [7,8].
2. Ethical Guidelines: Development of standardized protocols addressing AI accountability, informed consent, and data protection is essential [4,6].
3. Policy Support: Hospitals and regulatory authorities should facilitate digital competence programs and incentivize AI adoption to enhance professional autonomy [9].
4. Integration Frameworks: A sociotechnical approach is critical, emphasizing alignment between AI tools, professional expertise, and institutional governance [10].

Limitations and Future Research

While the study provides robust quantitative insights, several limitations exist. The cross-sectional design restricts causal inference. Self-reported measures may be influenced by social desirability bias, particularly regarding ethical awareness. Rural healthcare facilities were underrepresented, limiting generalizability to smaller hospitals with lower AI exposure. Future research should adopt longitudinal designs or mixed methods to examine the dynamic effects of AI integration over time and across diverse institutional settings.

Conclusion and Policy Implications

Conclusion

This study examined the integration of Artificial Intelligence (AI) in diagnostic radiography in Pakistan, focusing on its impact on diagnostic accuracy, ethical awareness, and professional autonomy. The findings indicate that AI integration significantly enhances diagnostic accuracy and strengthens professional autonomy through improved ethical awareness. Digital competence emerged as a key moderator, with radiographers possessing higher digital literacy experiencing greater autonomy benefits. These results highlight that successful AI adoption is not solely technology-driven; it requires complementary investments in professional skills, ethical understanding, and organizational support.

The research also underscores the importance of a sociotechnical perspective, wherein AI tools, radiographers' competencies, and institutional frameworks interact to determine outcomes. By integrating ethical literacy and digital proficiency into radiography practice, healthcare institutions can ensure that AI improves diagnostic quality while maintaining professional standards. This study provides empirical evidence for Pakistan, a context where AI adoption in healthcare is nascent, and regulatory and training frameworks are still developing.

Policy Implications

- 1. AI Training and Digital Competence Development:** Healthcare institutions and professional bodies, such as the Pakistan Society of Radiographers, should implement structured AI training programs to enhance radiographers' technical skills and digital literacy. Training should include practical use of AI software, understanding algorithmic limitations, and troubleshooting errors, thereby improving diagnostic accuracy and autonomy [1,2].
- 2. Ethical Guidelines and Standard Operating Procedures:** Regulatory authorities should develop AI-specific ethical guidelines, covering informed consent, accountability, patient privacy, and decision-making boundaries. These guidelines will help radiographers navigate ethical dilemmas arising from AI-assisted diagnoses and maintain professional integrity [3,4].
- 3. Infrastructure and Resource Allocation:** Investment in AI-compatible imaging hardware, software, and IT support is essential, especially in public hospitals that serve high patient volumes. Policies should prioritize equitable access to AI technology across urban and semi-urban centers to reduce disparities in healthcare delivery [5].

4. **Integration into Radiography Curricula:** Radiography degree programs and continuing professional development (CPD) courses should embed AI education, including modules on algorithmic reasoning, diagnostic validation, and ethics in AI healthcare applications. This will prepare the future workforce to effectively integrate AI into clinical practice [6,7].
5. **Monitoring and Evaluation:** Healthcare institutions should establish monitoring frameworks to evaluate the impact of AI on diagnostic accuracy, workflow efficiency, and professional autonomy. Data-driven evaluation will inform iterative improvements and policy adjustments, ensuring sustainable AI integration [2,8].
6. **Research and Development Support:** Policymakers should encourage local research on AI applications in radiography, including partnerships between universities, hospitals, and tech companies. Context-specific research will help tailor AI tools to local healthcare needs and regulatory conditions [9].

Final Remarks

The integration of AI in diagnostic radiography represents a transformative opportunity for Pakistan's healthcare sector. When accompanied by training, ethical awareness, and institutional support, AI can enhance diagnostic accuracy, empower radiographers, and improve patient care outcomes. This study provides actionable evidence to guide policymakers, hospital administrators, and professional bodies in designing comprehensive AI adoption strategies that are technically robust, ethically grounded, and contextually relevant.

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