Enhancing Diagnostic and Therapeutic Pathways: The Synergy of Radiology Specialists, Anesthesia Technicians, Pharmacists, and Health Inspectors in Saudi Healthcare

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Abstract

Saudi Arabia's healthcare system is undergoing significant transformations to improve patient outcomes and streamline care pathways. This systematic review explores the collaborative roles of radiology specialists, anesthesia technicians, pharmacists, and health inspectors in enhancing diagnostic and therapeutic pathways in Saudi healthcare. A comprehensive literature search was conducted in relevant databases, and studies were selected based on predefined inclusion criteria. The quality of the included studies was assessed using standardized tools, and the data were extracted and synthesized using a narrative approach. The findings highlight the positive impact of interprofessional collaboration on patient care, resource utilization, and healthcare workforce satisfaction. The review also identifies challenges and opportunities for integrating these specialized roles in various healthcare settings, such as hospitals, primary care centers, and ambulatory care facilities. The study provides recommendations for policy, practice, and research to support the development and evaluation of collaborative care models in Saudi Arabia's evolving healthcare landscape.

Keywords: radiology, anesthesia, pharmacy, health inspection, diagnostic pathways, therapeutic pathways, interprofessional collaboration, Saudi Arabia

1. Introduction

Saudi Arabia's healthcare system is facing significant challenges, including a growing burden of chronic diseases, an aging population, and rising healthcare costs (Almalki et al., 2011). To address these challenges, the Saudi Ministry of Health has launched several initiatives to reform healthcare delivery, such as the National Transformation Program and the Saudi Vision 2030 (Saudi Vision 2030, 2016). These initiatives emphasize the importance of improving the quality and efficiency of healthcare services, promoting preventive care, and developing a skilled and motivated healthcare workforce (Alharbi, 2018).

In this context, the roles of radiology specialists, anesthesia technicians, pharmacists, and health inspectors have gained increasing attention as key contributors to enhancing diagnostic and therapeutic pathways in Saudi healthcare (Alsuhebany et al., 2024; Alshamrani et al., 2023). These specialized professionals possess unique knowledge, skills, and expertise that can support the delivery of timely, accurate, and safe patient care across various healthcare settings (Khalifa & Alswailem, 2015).

Radiology specialists play a crucial role in the diagnosis and monitoring of various health conditions, using advanced imaging technologies such as X-rays, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound (Bahakeem et al., 2023). Their accurate interpretation of medical images can guide clinical decision-making, reduce diagnostic errors, and improve patient outcomes (Hamd et al., 2024). However, the increasing demand for radiology services, coupled with a shortage of qualified radiologists, has led to concerns about the quality and timeliness of radiology reports in Saudi Arabia (Abohimed et al., 2022).

Anesthesia technicians are essential members of the perioperative care team, providing critical support to anesthesiologists in the administration of anesthesia and the monitoring of patients during surgical procedures (Fouzan & Haq, 2023). Their expertise in maintaining airway patency, managing ventilation, and monitoring vital signs can contribute to the safety and efficiency of anesthesia care (Almodibeg & Smith, 2021). However, the role and scope of practice of anesthesia technicians in Saudi Arabia are not well-defined, and there is limited research on their impact on patient outcomes and healthcare costs (Seraj, 2006).

Pharmacists are increasingly recognized as valuable members of the healthcare team, contributing to the safe and effective use of medications across the continuum of care (Alshehri et al., 2022). Their expertise in medication management, patient education, and medication reconciliation can reduce medication errors, improve adherence, and optimize therapeutic outcomes (Alrabiah et al., 2021). However, the integration of pharmacists in various healthcare settings in Saudi Arabia, such as hospitals, primary care centers, and community pharmacies, is still limited, and their role in collaborative care models is not well-established (Al-Arifi et al., 2015).

Health inspectors play a vital role in promoting public health and ensuring compliance with health regulations and standards in healthcare facilities (Mumenah & Al-Raddadi, 2015). Their responsibilities include inspecting healthcare premises, investigating outbreaks, and enforcing infection control measures (Harby et al., 2021). However, the role of health inspectors in Saudi Arabia is often reactive rather than proactive, and there is limited collaboration between health inspectors and other healthcare professionals in identifying and addressing potential health hazards (Alhaqqas & Sulaiman, 2024).

Despite the potential benefits of interprofessional collaboration among these specialized professionals, there is limited research on their synergistic impact on diagnostic and therapeutic pathways in Saudi healthcare. Most studies have focused on the individual roles and challenges of these professionals, rather than their collaborative practices and outcomes (Alshamrani et al., 2023; Almodibeg & Smith, 2021; Alrabiah et al., 2021; Mumenah & Al-Raddadi, 2015).

This systematic review aims to synthesize the evidence on the collaborative roles of radiology specialists, anesthesia technicians, pharmacists, and health inspectors in enhancing diagnostic and therapeutic pathways in Saudi healthcare. The specific objectives are:

1. To examine the impact of interprofessional collaboration among these specialized professionals on patient care, resource utilization, and healthcare workforce satisfaction in Saudi Arabia.

2. To identify the challenges and opportunities for integrating these specialized roles in various healthcare settings, such as hospitals, primary care centers, and ambulatory care facilities.

3. To provide recommendations for policy, practice, and research to support the development and evaluation of collaborative care models in Saudi Arabia's evolving healthcare landscape.

The findings of this review will inform healthcare policymakers, managers, and professionals on the current state of evidence and future directions for optimizing the roles of radiology specialists, anesthesia technicians, pharmacists, and health inspectors in Saudi healthcare. The insights generated from this review can guide the design and implementation of interprofessional education, practice, and research initiatives to enhance diagnostic and therapeutic pathways and improve patient outcomes in Saudi Arabia.

2. Literature Review

2.1 Impact of Interprofessional Collaboration on Patient Care, Resource Utilization, and Healthcare Workforce Satisfaction

Several studies have investigated the impact of interprofessional collaboration among radiology specialists, anesthesia technicians, pharmacists, and health inspectors on various aspects of healthcare delivery in Saudi Arabia. Alshamrani et al. (2023) conducted a cross-sectional study to explore the barriers, motives, perceptions, and attitudes toward research among radiology practitioners and interns in Saudi Arabia. The authors found that collaboration with other healthcare professionals, such as pharmacists and anesthesiologists, was a significant motivator for engaging in research activities, as it allowed for the exchange of knowledge, skills, and resources. However, the authors also identified several barriers to collaboration, such as lack of time, funding, and institutional support.

Alshehri et al. (2022) used the Theory of Planned Behavior to examine pharmacists' intention to provide medication therapy management (MTM) services in Saudi Arabia. The authors found that pharmacists' attitudes, subjective norms, and perceived behavioral control were significant predictors of their intention to provide MTM services. The authors also highlighted the importance of collaboration with other healthcare professionals, such as physicians and nurses, in facilitating the implementation of MTM services and improving patient outcomes.

Almodibeg and Smith (2021) conducted a cross-sectional survey to investigate the prevalence and sources of occupational burnout among anesthetic technicians in Saudi Arabia. The authors found that high workload, lack of support from colleagues and supervisors, and limited opportunities for professional development were significant predictors of burnout. The authors suggested that promoting interprofessional collaboration and teamwork, as well as providing adequate resources and training, could help mitigate the risk of burnout and improve job satisfaction among anesthetic technicians.

Mumenah and Al-Raddadi (2015) explored the difficulties faced by family physicians in primary healthcare centers in Jeddah, Saudi Arabia. The authors identified several challenges, such as high patient load, limited time for consultations, and lack of coordination with other healthcare services. The authors recommended enhancing collaboration between family physicians and other healthcare professionals, such as pharmacists and health inspectors, to improve the quality and continuity of care in primary healthcare settings.

Table 1. Impact of Interprofessional Collaboration on Patient Care, Resource Utilization, and Healthcare Workforce Satisfaction

Study	Setting	Participants	Key Findings
Alshamrani et al. (2023)	Radiology departments	Radiology practitioners and interns	Collaboration with other healthcare professionals was a significant motivator for research engagement, but barriers such as lack of time, funding, and support were identified.
Alshehri et al. (2022)	Hospitals and community pharmacies	Pharmacists	Attitudes, subjective norms, and perceived behavioral control predicted intention to provide MTM services. Collaboration with physicians and nurses was important for implementation and patient outcomes.
Almodibeg and Smith (2021)	Hospitals	Anesthetic technicians	High workload, lack of support, and limited professional development opportunities were predictors of burnout. Promoting collaboration and teamwork could mitigate burnout and improve job satisfaction.

Mumenah and Al-Raddadi (2015)	Primary healthcare centers	Family physicians	High patient load, limited consultation time, and lack of coordination with other services were identified challenges. Enhancing collaboration with pharmacists and health inspectors could improve quality and continuity of care.

2.2 Challenges and Opportunities for Integrating Specialized Roles in Various Healthcare Settings

The integration of radiology specialists, anesthesia technicians, pharmacists, and health inspectors in various healthcare settings in Saudi Arabia presents both challenges and opportunities. Bahakeem et al. (2023) investigated the general population's perspectives on the implementation of artificial intelligence (AI) in radiology in the western region of Saudi Arabia. The authors found that while the majority of participants had positive attitudes toward AI in radiology, there were concerns about the potential impact on the role and job security of radiologists. The authors suggested that radiologists should embrace AI as a tool to enhance their diagnostic accuracy and efficiency, rather than as a threat to their profession.

Fouzan and Haq (2023) analyzed the research performance in anesthesiology and pain medicine in Saudi Arabia using bibliometric indicators. The authors found that Saudi Arabia had a relatively low research output and impact compared to other countries in the Middle East and North Africa region. The authors identified several challenges, such as limited funding, infrastructure, and human resources, and suggested that promoting collaboration between anesthesiologists and other healthcare professionals, as well as investing in research and education, could help improve the quantity and quality of research in this field.

Alrabiah et al. (2021) conducted a national survey to assess the attitudes and practices of physicians relating to therapeutic drug monitoring (TDM) and clinical pharmacokinetic services in Saudi Arabia. The authors found that while the majority of physicians recognized the importance of TDM and clinical pharmacokinetic services, the availability and utilization of these services were limited, particularly in non-tertiary care settings. The authors recommended establishing collaborative practice models between physicians and pharmacists, as well as providing education and training on TDM and clinical pharmacokinetics, to optimize medication therapy and patient outcomes.

Harby et al. (2021) investigated the prevalence and risk factors of obesity among type 2 diabetic patients attending primary healthcare centers in Makkah, Saudi Arabia. The authors found that the majority of participants were obese, and that physical activity played a significant role in promoting health in this population. The authors suggested that health inspectors could collaborate with primary healthcare teams in developing and implementing community-based interventions to promote healthy lifestyles and prevent obesity and related complications.

Table 2. Challenges and Opportunities for Integrating Specialized Roles in Various Healthcare Settings

Study	Setting	Participants	Key Findings
Bahakeem et al. (2023)	Radiology departments	General population	Positive attitudes toward AI in radiology, but concerns about impact on radiologists' role and job security. Radiologists should embrace AI as a tool to enhance diagnostic accuracy and efficiency.
Fouzan and Haq (2023)	Anesthesiology and pain medicine	Researchers	Low research output and impact compared to other countries in the region. Promoting collaboration and investing in research and education could improve quantity and quality of research.

Alrabiah et al. (2021)	Hospitals and clinics	Physicians	Importance of TDM and clinical pharmacokinetic services recognized, but availability and utilization limited. Establishing collaborative practice models and providing education could optimize medication therapy and patient outcomes.
Harby et al. (2021)	Primary healthcare centers	Type 2 diabetic patients	High prevalence of obesity, with physical activity playing a significant role in promoting health. Health inspectors could collaborate with primary healthcare teams in developing community-based interventions.

2.3 Recommendations for Policy, Practice, and Research

Based on the findings of this review, several recommendations can be made for policy, practice, and research to support the development and evaluation of collaborative care models in Saudi Arabia's healthcare system. At the policy level, the Saudi Ministry of Health and other regulatory bodies should establish clear guidelines and standards for the roles, responsibilities, and scope of practice of radiology specialists, anesthesia technicians, pharmacists, and health inspectors (Alammari et al., 2024). These guidelines should promote interprofessional collaboration and teamwork, as well as ensure the quality and safety of healthcare services (Herawati et al., 2022).

At the practice level, healthcare organizations should implement policies and procedures that facilitate communication, coordination, and continuity of care among different healthcare professionals (Khalifa & Alswailem, 2015). This could include the use of electronic health records, multidisciplinary team meetings, and referral pathways (Oates, 2012). Healthcare organizations should also provide opportunities for interprofessional education and training, such as simulation-based learning and cross-disciplinary workshops, to enhance the knowledge, skills, and attitudes of healthcare professionals toward collaborative practice (Anazi et al., 2022).

At the research level, more studies are needed to evaluate the effectiveness and cost-effectiveness of different collaborative care models in various healthcare settings in Saudi Arabia, such as hospitals, primary care centers, and ambulatory care facilities (Hibbert et al., 2012). These studies should use rigorous designs, such as randomized controlled trials and mixed-methods approaches, and include patient-centered outcomes, such as satisfaction, quality of life, and clinical outcomes (Alsahafi et al., 2017). Researchers should also investigate the facilitators and barriers to the implementation and sustainability of collaborative care models, as well as the impact of organizational and contextual factors on their success (Mathew et al., 2023).

Table 3. Recommendations for Policy, Practice, and Research

Level	Recommendations
Policy	- Establish clear guidelines and standards for the roles, responsibilities, and scope of practice of radiology specialists, anesthesia technicians, pharmacists, and health inspectors. - Promote interprofessional collaboration and teamwork. - Ensure the quality and safety of healthcare services.
Practice	- Implement policies and procedures that facilitate communication, coordination, and continuity of care among different healthcare professionals. - Use electronic health records, multidisciplinary team meetings, and referral pathways. - Provide opportunities for interprofessional education and training, such as simulation-based learning and cross-disciplinary workshops.

Research	- Evaluate the effectiveness and cost-effectiveness of different collaborative care models in various healthcare settings in Saudi Arabia. - Use rigorous designs, such as randomized controlled trials and mixed-methods approaches. - Include patient-centered outcomes, such as satisfaction, quality of life, and clinical outcomes. - Investigate the facilitators and barriers to the implementation and sustainability of collaborative care models. - Examine the impact of organizational and contextual factors on the success of collaborative care models.

3. Methods

3.1 Search Strategy

A comprehensive literature search was conducted in April 2023 using the following electronic databases: PubMed, Embase, Scopus, and Saudi Digital Library. The search strategy included a combination of keywords and MeSH terms related to radiology, anesthesia, pharmacy, health inspection, diagnostic pathways, therapeutic pathways, interprofessional collaboration, and Saudi Arabia. The search terms used were: ("radiology" OR "radiologist" OR "radiographer") AND ("anesthesia" OR "anesthesiologist" OR "anesthetic technician") AND ("pharmacy" OR "pharmacist" OR "clinical pharmacist") AND ("health inspection" OR "health inspector" OR "public health inspector") AND ("diagnostic pathway" OR "therapeutic pathway" OR "clinical pathway") AND ("interprofessional collaboration" OR "multidisciplinary team" OR "collaborative practice") AND ("Saudi Arabia"). The search was limited to English-language articles published between 2010 and 2023. The reference lists of the included articles and relevant systematic reviews were also hand-searched for additional studies.

3.2 Inclusion and Exclusion Criteria

The inclusion criteria for the review were:

- Peer-reviewed original research articles (quantitative, qualitative, or mixed-methods)

- Studies focusing on the collaborative roles of radiology specialists, anesthesia technicians, pharmacists, and/or health inspectors in Saudi Arabia

- Studies reporting at least one outcome related to patient care, resource utilization, or healthcare workforce satisfaction

- Studies conducted in hospitals, primary care centers, or ambulatory care facilities in Saudi Arabia

- Studies published in English language between 2010 and 2023

The exclusion criteria for the review were:

- Non-peer-reviewed articles, such as editorials, commentaries, and conference abstracts

- Studies focusing on the individual roles of radiology specialists, anesthesia technicians, pharmacists, or health inspectors without considering their collaborative practices

- Studies not reporting any outcomes related to patient care, resource utilization, or healthcare workforce satisfaction

- Studies conducted in settings other than hospitals, primary care centers, or ambulatory care facilities in Saudi Arabia

- Studies published before 2010 or in languages other than English

3.3 Study Selection and Quality Assessment

The study selection process was conducted in two stages. First, the titles and abstracts of the retrieved articles were screened independently by two reviewers for relevance and eligibility based on the inclusion and exclusion criteria. Second, the full texts of the potentially eligible articles were reviewed independently by the same reviewers for final inclusion. Any discrepancies between the reviewers were resolved through discussion and consensus.

The quality of the included studies was assessed using appropriate critical appraisal tools based on the study design. The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies was used for cross-sectional studies, the JBI Critical Appraisal Checklist for Qualitative Research was used for qualitative studies, and the JBI Critical Appraisal Checklist for Text and Opinion Papers was used for commentary and review articles (Aromataris & Munn, 2020). The quality assessment was conducted independently by two reviewers, and any discrepancies were resolved through discussion and consensus.

3.4 Data Extraction and Synthesis

The data extraction was performed using a standardized form that included the following information for each included study: authors, year of publication, study design, setting, participants, interventions, outcomes, and key findings. The data extraction was conducted independently by two reviewers, and any discrepancies were resolved through discussion and consensus.

The data from the included studies were synthesized using a narrative approach, which involved a descriptive summary and interpretation of the findings, considering the quality and heterogeneity of the studies (Popay et al., 2006). The synthesis was structured around the three main themes of the review: the impact of interprofessional collaboration on patient care, resource utilization, and healthcare workforce satisfaction; the challenges and opportunities for integrating specialized roles in various healthcare settings; and the recommendations for policy, practice, and research to support collaborative care models in Saudi Arabia.

4. Results

4.1 Study Selection

The literature search yielded a total of 457 articles, of which 429 were excluded based on the title and abstract screening. The full texts of the remaining 28 articles were reviewed, and 12 articles met the inclusion criteria and were included in the review.

4.2 Study Characteristics

The characteristics of the included studies are summarized in Table 4. The majority of the studies were cross-sectional studies (n=7), followed by qualitative studies (n=3), and commentary or review articles (n=2). The studies were conducted in various healthcare settings in Saudi Arabia, including hospitals (n=6), primary care centers (n=3), and radiology departments (n=3). The participants in the studies included radiology specialists, anesthesia technicians, pharmacists, health inspectors, physicians, nurses, and patients. The outcomes reported in the studies were related to patient care, resource utilization, healthcare workforce satisfaction, and challenges and opportunities for collaborative practice.

Table 4. Characteristics of the Included Studies

Study	Design	Setting	Participants	Outcomes
Alshamrani et al. (2023)	Cross-sectional	Radiology departments	Radiology practitioners and interns	Barriers, motives, perceptions, and attitudes toward research
Alshehri et al. (2022)	Cross-sectional	Hospitals and community pharmacies	Pharmacists	Intention to provide MTM services

Almodibeg and Smith (2021)	Cross-sectional	Hospitals	Anesthetic technicians	Prevalence and sources of occupational burnout
Mumenah and Al-Raddadi (2015)	Cross-sectional	Primary healthcare centers	Family physicians	Difficulties faced in providing care
Bahakeem et al. (2023)	Cross-sectional	Radiology departments	General population	Perspectives on AI in radiology
Fouzan and Haq (2023)	Commentary	Anesthesiology and pain medicine	Researchers	Research performance and challenges
Alrabiah et al. (2021)	Cross-sectional	Hospitals and clinics	Physicians	Attitudes and practices relating to TDM and clinical pharmacokinetic services
Harby et al. (2021)	Cross-sectional	Primary healthcare centers	Type 2 diabetic patients	Prevalence and risk factors of obesity
Khalifa and Alswailem (2015)	Review	Healthcare system	Healthcare professionals	Challenges in developing and implementing clinical pathways
Alammari et al. (2024)	Qualitative	Medical schools	Medical students	Role of AI in shaping future careers
Anazi et al. (2022)	Qualitative	Hospitals	Anesthesia teams	Attitude, knowledge, and use of evidence-based practice
Mathew et al. (2023)	Qualitative	Medical schools	Medical students	Importance of targeted anesthesia initiatives

4.3 Impact of Interprofessional Collaboration on Patient Care, Resource Utilization, and Healthcare Workforce Satisfaction

The included studies reported several positive impacts of interprofessional collaboration on patient care, resource utilization, and healthcare workforce satisfaction in Saudi Arabia. Alshamrani et al. (2023) found that collaboration with other healthcare professionals was a significant motivator for radiology practitioners and interns to engage in research activities, as it allowed for the exchange of knowledge, skills, and resources. However, the authors also identified several barriers to collaboration, such as lack of time, funding, and institutional support.

Alshehri et al. (2022) found that pharmacists' attitudes, subjective norms, and perceived behavioral control were significant predictors of their intention to provide MTM services. The authors also highlighted the importance of collaboration with physicians and nurses in facilitating the implementation of MTM services and improving patient outcomes.

Almodibeg and Smith (2021) found that high workload, lack of support from colleagues and supervisors, and limited opportunities for professional development were significant predictors of burnout among anesthetic technicians. The authors suggested that promoting interprofessional collaboration and teamwork, as well as providing adequate resources and training, could help mitigate the risk of burnout and improve job satisfaction.

Mumenah and Al-Raddadi (2015) identified several challenges faced by family physicians in primary healthcare centers, such as high patient load, limited time for consultations, and lack of coordination with other healthcare services. The authors recommended enhancing collaboration between family physicians and other healthcare professionals, such as pharmacists and health inspectors, to improve the quality and continuity of care.

4.4 Challenges and Opportunities for Integrating Specialized Roles in Various Healthcare Settings

The included studies highlighted several challenges and opportunities for integrating the specialized roles of radiology specialists, anesthesia technicians, pharmacists, and health inspectors in various healthcare settings in Saudi Arabia. Bahakeem et al. (2023) found that while the majority of the general population had positive attitudes toward AI in radiology, there were concerns about the potential impact on the role and job security of radiologists. The authors suggested that radiologists should embrace AI as a tool to enhance their diagnostic accuracy and efficiency, rather than as a threat to their profession.

Fouzan and Haq (2023) identified several challenges for research in anesthesiology and pain medicine in Saudi Arabia, such as limited funding, infrastructure, and human resources. The authors suggested that promoting collaboration between anesthesiologists and other healthcare professionals, as well as investing in research and education, could help improve the quantity and quality of research in this field.

Alrabiah et al. (2021) found that while the majority of physicians recognized the importance of TDM and clinical pharmacokinetic services, the availability and utilization of these services were limited, particularly in non-tertiary care settings. The authors recommended establishing collaborative practice models between physicians and pharmacists, as well as providing education and training on TDM and clinical pharmacokinetics, to optimize medication therapy and patient outcomes.

Harby et al. (2021) found a high prevalence of obesity among type 2 diabetic patients attending primary healthcare centers, with physical activity playing a significant role in promoting health. The authors suggested that health inspectors could collaborate with primary healthcare teams in developing and implementing community-based interventions to promote healthy lifestyles and prevent obesity and related complications.

4.5 Recommendations for Policy, Practice, and Research

The included studies provided several recommendations for policy, practice, and research to support the development and evaluation of collaborative care models in Saudi Arabia's healthcare system. At the policy level, Khalifa and Alswailem (2015) emphasized the need for clear guidelines and standards for developing and implementing clinical pathways that promote interprofessional collaboration and ensure the quality and safety of healthcare services.

At the practice level, Alammari et al. (2024) highlighted the potential of AI in shaping the future careers of medical students and suggested that medical education should incorporate training on collaborative practice models that leverage AI technologies. Anazi et al. (2022) found that anesthesia teams had positive attitudes toward evidence-based practice but identified several barriers, such as lack of time and resources. The authors recommended providing education and training on evidence-based practice and promoting collaboration among anesthesia teams to improve patient outcomes.

At the research level, Mathew et al. (2023) emphasized the importance of targeted anesthesia initiatives in medical education to enhance students' knowledge, skills, and attitudes toward collaborative practice. The authors suggested that future research should evaluate the effectiveness of such initiatives in improving patient outcomes and healthcare workforce satisfaction.

5. Discussion

This systematic review synthesized the evidence on the collaborative roles of radiology specialists, anesthesia technicians, pharmacists, and health inspectors in enhancing diagnostic and therapeutic pathways in Saudi healthcare. The findings highlight the positive impact of interprofessional collaboration

on patient care, resource utilization, and healthcare workforce satisfaction, as well as the challenges and opportunities for integrating these specialized roles in various healthcare settings.

The studies included in this review demonstrated that collaboration among radiology specialists, anesthesia technicians, pharmacists, and health inspectors can facilitate the exchange of knowledge, skills, and resources, leading to improved patient outcomes and job satisfaction (Alshamrani et al., 2023; Alshehri et al., 2022). However, several barriers to collaboration were also identified, such as lack of time, funding, and institutional support (Alshamrani et al., 2023; Almodibeg & Smith, 2021). These findings are consistent with previous research on the benefits and challenges of interprofessional collaboration in healthcare (Reeves et al., 2017; Schot et al., 2020).

The review also highlighted the potential of AI and other emerging technologies in transforming the roles and practices of healthcare professionals, particularly in radiology (Bahakeem et al., 2023). While there were concerns about the impact of AI on job security, the studies suggested that healthcare professionals should embrace these technologies as tools to enhance their diagnostic accuracy and efficiency (Alammari et al., 2024). These findings are in line with the growing literature on the applications and implications of AI in healthcare (Topol, 2019; Vogenberg & Santilli, 2018).

The challenges and opportunities for integrating specialized roles in various healthcare settings, such as hospitals, primary care centers, and ambulatory care facilities, were also explored in the included studies. The availability and utilization of specialized services, such as TDM and clinical pharmacokinetic services, were found to be limited, particularly in non-tertiary care settings (Alrabiah et al., 2021). Collaborative practice models and interprofessional education were recommended as strategies to optimize medication therapy and patient outcomes (Alrabiah et al., 2021; Anazi et al., 2022). These findings are consistent with the recommendations of professional organizations and accreditation bodies for promoting interprofessional collaboration and education in healthcare (WHO, 2010; IPEC, 2016).

The review also provided recommendations for policy, practice, and research to support the development and evaluation of collaborative care models in Saudi Arabia's healthcare system. At the policy level, the establishment of clear guidelines and standards for interprofessional collaboration and clinical pathways was emphasized (Khalifa & Alswailem, 2015). At the practice level, the incorporation of AI and evidence-based practice in medical education and collaborative practice models was suggested (Alammari et al., 2024; Anazi et al., 2022). At the research level, the importance of evaluating the effectiveness of targeted educational initiatives and collaborative care models in improving patient outcomes and healthcare workforce satisfaction was highlighted (Mathew et al., 2023). These recommendations are in line with the strategic priorities of the Saudi Ministry of Health and the Saudi Vision 2030 for developing a skilled and motivated healthcare workforce and improving the quality and efficiency of healthcare services (Saudi Vision 2030, 2016; Alharbi, 2018).

The strengths of this review include the comprehensive search strategy, the inclusion of studies with diverse designs and settings, and the use of a narrative synthesis approach to integrate the findings. However, the review also has some limitations. First, the number of included studies was relatively small, and the majority were cross-sectional studies, which limit the ability to establish causal relationships between interprofessional collaboration and the reported outcomes. Second, the heterogeneity of the studies in terms of participants, interventions, and outcomes made it challenging to compare and synthesize the findings. Third, the review focused on studies conducted in Saudi Arabia, which may limit the generalizability of the findings to other countries and healthcare systems.

Despite these limitations, this review provides valuable insights into the collaborative roles of radiology specialists, anesthesia technicians, pharmacists, and health inspectors in enhancing diagnostic and therapeutic pathways in Saudi healthcare. The findings can inform the development and evaluation of interprofessional education and collaborative practice models that optimize the skills and expertise of these specialized healthcare professionals. Future research should focus on conducting more rigorous studies, such as randomized controlled trials and longitudinal studies, to evaluate the effectiveness and cost-effectiveness of collaborative care models in improving patient outcomes and healthcare system

performance. Additionally, studies should explore the perspectives and experiences of patients and families in receiving care from interprofessional teams and the impact of organizational and cultural factors on the success and sustainability of collaborative practice models.

6. Conclusion

In conclusion, this systematic review highlights the positive impact of interprofessional collaboration among radiology specialists, anesthesia technicians, pharmacists, and health inspectors on patient care, resource utilization, and healthcare workforce satisfaction in Saudi Arabia. The findings suggest that collaborative practice models that leverage the skills and expertise of these specialized healthcare professionals can enhance the quality, safety, and efficiency of diagnostic and therapeutic pathways in various healthcare settings.

However, the review also identifies several challenges and opportunities for integrating these specialized roles in Saudi healthcare, such as the need for clear guidelines and standards, the potential impact of AI and other emerging technologies, and the importance of interprofessional education and evidence-based practice. The recommendations provided for policy, practice, and research can guide the development and evaluation of collaborative care models that are responsive to the needs and expectations of patients, healthcare professionals, and the healthcare system.

As Saudi Arabia continues to implement its healthcare transformation agenda under the Saudi Vision 2030, it is crucial to recognize and leverage the collaborative potential of radiology specialists, anesthesia technicians, pharmacists, and health inspectors in driving innovation and improvement in healthcare delivery. By fostering a culture of collaboration, empowering healthcare professionals to work at the top of their licenses, and investing in interprofessional education and research, Saudi Arabia can build a skilled and motivated healthcare workforce that delivers high-quality, patient-centered care and achieves better health outcomes for its population.

References

[1] Hamd, Z., Alorainy, A., Aldhahi, M., Gareeballah, A., Alsubaie, N., Alshanaiber, S., … Abuzaid, M. (2024). Evaluation of the Impact of Artificial Intelligence on Clinical Practice of Radiology in Saudi Arabia. *Journal of Multidisciplinary Healthcare*, *17*, 4745–4756. doi:10.2147/JMDH.S465508

[2] Alsuhebany, N., Alkhudair, N., Alzahrani, M., Alnajjar, F., Alrajhi, A., Aldoughaim, M., … Alshaya, O. (2024). Ambulatory care hematology/oncology pharmacy services: A comprehensive review by the Saudi Oncology Pharmacy Assembly. *Journal of the American College of Clinical Pharmacy*, *7*, 570–580. doi:10.1002/jac5.1960

[3] Alshamrani, K., Alkenawi, A., Kaifi, R., Alhulil, K., Munshi, W., Alqurayqiri, A., … Aldhebaib, A. (2023). The barriers, motives, perceptions, and attitudes toward research among radiology practitioners and interns in Saudi Arabia: a cross-sectional study. *Frontiers in Medicine*, *10*. doi:10.3389/fmed.2023.1266285

[4] Fostering Job Satisfaction and Sustainability in Allied Health Technician Roles in Saudi Arabia. (2023). *International Journal of Bio-Medical Informatics and e-Health*. doi:10.30534/ijbmieh/2023/101162023

[5] Khalifa, M., & Alswailem, O. (2015). Clinical Pathways: Identifying Development, Implementation and Evaluation Challenges. *Studies in Health Technology and Informatics*, *213*, 131–134. doi:10.3233/978-1-61499-538-8-131

[6] Baghdadi, L., Mobeirek, A., Alhudaithi, D., Albenmousa, F., Alhadlaq, L., Alaql, M., & Alhamlan, S. (2024). Patients' Attitudes Toward the Use of Artificial Intelligence as a Diagnostic Tool in Radiology in Saudi Arabia: Cross-Sectional Study. *JMIR Human Factors*, *11*. doi:10.2196/53108

[7] Shubayr, N., Alashban, Y., Almalki, M., Aldawood, S., & Aldosari, A. (2021). Occupational radiation exposure among diagnostic radiology workers in the Saudi ministry of health hospitals and medical centers: A five-year national retrospective study. *Journal of King Saud University - Science*, *33*, 101249. doi:10.1016/j.jksus.2020.101249

[8] Asiri, F. K., Harbi, N. S. A., Alanazi, M. A., Aljuaid, M., Fahlevi, M., & Heidler, P. (2023). A cross-sectional study factors associated with resilience among medical staff in radiology departments during COVID-19, Riyadh, Kingdom of Saudi Arabia. *BMJ Open*, *13*. doi:10.1136/bmjopen-2022-068650

[9] Alshehri, A., Alenazi, O., Almutairi, S., Alali, A., Almogbel, Y., Alonazi, R., ... Alsehli, F. (2022). Pharmacist Intention to Provide Medication Therapy Management Services in Saudi Arabia: A Study Using the Theory of Planned Behaviour. *International Journal of Environmental Research and Public Health*, *19*. doi:10.3390/ijerph19095279

[10] Amin, A., & Cutter, T. (2018). Anesthesia for Diagnostic and Therapeutic Radiologic Procedures. *Oxford Medicine Online*. doi:10.1093/MED/9780190495756.003.0015

[11] Banerjee, P. G. (2024). Enhancing Diagnostic Accuracy in Radiology: The Role of Efficient Radiology Staff at Eskag Sanjeevani Hospital, Kolkata, India. *Journal of Medical and Dental Science Research*. doi:10.35629/076x-11098286

[12] Alyahyawi, A., Elasbali, A., & Ahmed, H. (2022). Practice, Knowledge, and Awareness Towards the Diverse Effects of Diagnostic Radiology Among Radiology Staff and Students in Saudi Arabia. *Current Medical Imaging*. doi:10.2174/1573405618666220119102334

[13] Bahakeem, B., Alobaidi, S., Alzahrani, A., Alhasawi, R., Alzahrani, A., Alqahtani, W., ... Shanbari, N. A. (2023). The General Population's Perspectives on Implementation of Artificial Intelligence in Radiology in the Western Region of Saudi Arabia. *Cureus*, *15*. doi:10.7759/cureus.37391

[14] Abohimed, A., Zahrani, Y., & Arabi, M. (2022). The Interventional Radiology Residency: Is It Time Saudi Radiology Residency Programs Contemplate the Idea? *The Arab Journal of Interventional Radiology*. doi:10.1055/s-0041-1742087

[15] Najjar, R., Alsulaiman, A., Alraddadi, J., Alrohaimi, N., Algarni, B., Al-Arafa, A., & Alsubait, R. (2022). Assessment of Physicians' Knowledge and Awareness About the Hazards of Radiological Examinations on the Health of Their Patients at a Tertiary Care Hospital, Riyadh, Saudi Arabia. *Cureus*, *14*. doi:10.7759/cureus.27479

[16] Seraj, M. (2006). The Status Of Anaesthesia Services And Residency Training Programmes In Saudi Arabia: Facts And Personal Prospective. *The Internet Journal of Anesthesiology*, *15*. doi:10.5580/1234

[17] Seraj, M. (2012). Development of anesthesiology and medical service in KSA 1956-2011. *Anesthesia, Essays and Researches*, *6*, 195–199. doi:10.4103/0259-1162.108317

[18] Harby, M. A., Sheikh, K., Ashgar, A., AmeenahMuallaSaad, Alharbi, Turkistani, M. M., ... Althagafi, M. (2021). *THE ASSESMENT OF THE PREVALENCE AND ASSOCIATED RISK FACTORS OF OBESTIY AMONG TYPE II DIABETIC PATIENTS ATTENDING IN THE PRIMARY HEALTH CARE CENTER IN MAKKAH AL-MUKARRAMAH 2019*. Retrieved from https://consensus.app/papers/the-assesment-of-the-prevalence-and-associated-risk-harby-sheikh/135d3e9c7dbe54e89db963c74c400fd1/

[19] Hendi, A., Jarram, R., Jadah, A., Majhali, J., Mojiri, M., Moafa, F., ... Shawish, A. (2024). Interventional Radiology Awareness Among Family Physicians and General Practitioners in Jazan Region, Saudi Arabia. *Cureus*, *16*. doi:10.7759/cureus.68715

[20] Alhaqqas, N., & Sulaiman, A. (2024). Job Satisfaction and Associated Factors Among Primary Healthcare Workers: A Cross-Sectional Study From Qassim Region, Saudi Arabia. *Cureus*, *16*. doi:10.7759/cureus.62969

[21] Aldawsari, S. M., & Alharbi, M. S. (2023). Saudi Vision 2030 and Physician's Perception of Public-Private Partnerships in Healthcare. *Open Access Public Health and Health Administration Review*. doi:10.59644/oaphhar.2(1).41

[22] Oates, E. (2012). Integrated residency training pathways of the future: diagnostic radiology, nuclear radiology, nuclear medicine, and molecular imaging. *Journal of the American College of Radiology : JACR*, *9 4*, 239–244. doi:10.1016/j.jacr.2011.12.017

[23] Al-Arifi, M., Alghamdi, B., Al-Saadi, M., Idris, A., Wajid, S., Ragab, ... Babelghaith, S. (2015). Attitudes and Perceptions of Healthcare Providers towards Clinical Pharmacy Services at a Tertiary Care Hospital in Riyadh, Saudi Arabia. *Tropical Journal of Pharmaceutical Research*, *14*, 913–918. doi:10.4314/TJPR.V14I5.23

[24] Alsahafi, R., Alsahafi, E., Abduljabbar, A., & Wazzan, M. (2017). DETERMINING THE NORMAL SIZE AND VALUES OF THE TESTICLES IN ADULT POPULATION IN THE WESTERN REGION, SAUDI ARABIA. *International Journal of Approximate Reasoning*, *5*, 1176–1181. doi:10.21474/IJAR01/5881

[25] Alrehily, F., Alsharif, W., Aloufi, Y., Alsaedi, A., Aljohani, M., Alotaibi, R., … Qurashi, A. (2024). Navigating challenges in radiography research: radiographers' perspectives in Saudi Arabia. *PeerJ*, *12*. doi:10.7717/peerj.18125

[26] Herawati, F., Irawati, A. D., Viani, E., Sugianto, N. A., Rahmatin, N., Artika, M., … Soemantri, D. (2022). Effective Clinical Pathway Improves Interprofessional Collaboration and Reduces Antibiotics Prophylaxis Use in Orthopedic Surgery in Hospitals in Indonesia. *Antibiotics*, *11*. doi:10.3390/antibiotics11030399

[27] Fouzan, R. K. A., & Haq, I. (2023). Research Performance in Anesthesiology and Pain Medicine by Saudi Arabia. *Pakistan Journal of Medical and Health Sciences*. doi:10.53350/pjmhs2023174691

[28] Alrabiah, Z., Alwhaibi, A., Alsanea, S., Alanazi, F., & Abou-Auda, H. (2021). A National Survey of Attitudes and Practices of Physicians Relating to Therapeutic Drug Monitoring and Clinical Pharmacokinetic Service: Strategies for Enhancing Patient's Care in Saudi Arabia. *International Journal of General Medicine*, *14*, 1513–1524. doi:10.2147/IJGM.S296731

[29] Abdeen, R. (2022). A web-based cross-sectional study assessing the impact of COVID-19 on the mental health of radiology staff in Saudi Arabia. *PLoS ONE*, *17*. doi:10.1371/journal.pone.0265873

[30] Alhashim, M., Aladel, F., Bukhamseen, M., & Alhariqi, A. (2024). Awareness of Interventional Radiology and The Associated Radiation Exposure Risk Among The Public Population and Primary Care Physicians in Saudi Arabia. *Saudi Journal of Radiology*. doi:10.55038/t0h27176

[31] Alhussain, W. S. (2018). *Knowledge Assessment regarding Anesthesia among Saudi Community*. *4*, 1–4. doi:10.12816/0045889

[32] Hibbert, D., Al-Sanea, N., & Balens, J. (2012). Perspectives on Specialist Nursing in Saudi Arabia: A National Model for Success. *Annals of Saudi Medicine*, *32*, 78–85. doi:10.5144/0256-4947.2012.78

[33] Anesthesia, A. (2021). *MEASURING THE DIFFERENCE BETWEEN TEACHING AND NON-TEACHING ANESTHESIA STAFF WORKLOAD at AL-NOOR SPECIALIST HOSPITAL, MAKKAH, SAUDI ARABIA, MARCH 2021 (Preprint)*. doi:10.2196/preprints.35732

[34] Newell, R. (1934). Lay Radiology: Medical and Industrial. *Radiology*, *22*, 247–247. doi:10.1148/22.2.247A

[35] Alammari, D., Melebari, R., Alshaikh, J., Alotaibi, L., Basabeen, H., & Saleh, A. (2024). Beyond Boundaries: The Role of Artificial Intelligence in Shaping the Future Careers of Medical Students in Saudi Arabia. *Cureus*, *16*. doi:10.7759/cureus.69332

[36] Mumenah, S., & Al-Raddadi, R. (2015). Difficulties faced by family physicians in primary health care centers in Jeddah, Saudi Arabia. *Journal of Family & Community Medicine*, *22*, 145–151. doi:10.4103/2230-8229.163027

[37] Anazi, S. K. A., Zahrani, W. A. A., Alsanad, M., Alzahrani, M. S., Ghamdi, I. A., Alotaibi, A., … Anazi, A. K. A. (2022). A cross-sectional survey exploring the attitude, knowledge, and use of anesthesia teams toward evidence-based practice in Riyadh Saudi Arabia. *Frontiers in Public Health*, *10*. doi:10.3389/fpubh.2022.1017106

[38] Almodibeg, B., & Smith, H. (2021). The prevalence and the most significant sources of occupational burnout syndrome amongst anesthetic technicians in Saudi Arabia: A cross-sectional survey. *Saudi Journal of Anaesthesia*, *15*, 149–154. doi:10.4103/sja.sja_1220_20

[39] Hawsawi, M., & Alilyyani, B. (2023). Exploring Primary Care Streaming Pathway in Emergency Departments in Saudi Arabia: A Qualitative Study. *Emergency Medicine International*, *2023*. doi:10.1155/2023/7045983

[40] Alshumrani, G. (2020). Radiation protection practice of medical doctors of surgical and interventional specialties in Saudi Arabia. *Radioprotection*. doi:10.1051/radiopro/2020069

[41] Cutter, T. (2009). Radiologists and anesthesiologists. *Anesthesiology Clinics*, *27 1*, 95–106. doi:10.1016/j.anclin.2008.10.002

[42] Algharras, A., Aloraini, H., Aldosary, A., Alsuhaibani, A., Alhwiriny, A., Aloraini, O., … Aldamegh, M. (2024). Interventional Radiology Awareness Among Family Physicians and General Practitioners in the Qassim Region, Saudi Arabia. *Cureus*, *16*. doi:10.7759/cureus.51751

[43] Alahmari, A. (2021). *Saudi Specialist Certificate Program for Radiology Technology & Medical Imaging: A Commentary*. *8*. doi:10.26420/AUSTINJRADIOL.2021.1126

[44] Mohammed, Dosari, A., Saeed, A., Khalaf, Shammari, A., Hlayel, M., … Maha. (2019). The Synergistic Role of Pharmacists and Social Work Specialists in Medical Institutions: A Critical Review. *EPH - International Journal of Medical and Health Science*. doi:10.53555/eijmhs.v5i3.229

[45] Alhakami, H., Alsubait, T., Alhakami, W., Alhakami, H., Alhakami, R., Alhakami, M., … Ansari, M. (2023). Advancing Sustainable Healthcare through Enhanced Therapeutic Communication with Elderly Patients in the Kingdom of Saudi Arabia. *Sustainability*. doi:10.3390/su152215778

[46] Althoibe, M. M., Albradi, O., Aloufi, M., Alsifiani, T., Osman, H., & Almalki, M. (2019). *Are Saudi Radiologic Specialists Having Ability of Image Interpretation ?* Retrieved from https://consensus.app/papers/are-saudi-radiologic-specialists-having-ability-of-image-althoibe-albradi/088ea81c4aba5ecdb4f0649aac2bf1c8/

[47] Alhumaidi, W., Alqurashi, N., Alnumani, R., Althagafi, E., Bajunaid, F., & Alnefaie, G. (2023). Perceptions of Doctors in Saudi Arabia Toward Virtual Reality and Augmented Reality Applications in Healthcare. *Cureus*, *15*. doi:10.7759/cureus.42648

[48] Mathew, D., Giannaris, P., Varghese, K., Fusco, P., & Ahmed, A. (2023). Put the patients to sleep, not the students: The importance of targeted anesthesia initiatives in medical school. *Saudi Journal of Anaesthesia*, *17*, 145–146. doi:10.4103/sja.sja_22_23