Critical Analysis of Radiology's Role in Early Detection of Chronic Diseases

Mohammed Saeed Saad ALHajri[1], Abdullah Mubarak Abdullah Alahmari[2], Mohammed Hamoud S Almutairi[3], Nasreen Abdullah Ahmed Al Ghareeb[4], Hamad Ahmed Alnajrani[5], Majed Ali Abdullah ALyami[6], Zahra Hilal Essa Alsayegh[7], Khalid Abdullah Othman Alshehri[8], Heba Adulmohsen Al matter[9], Esraa sameer saeed alsinan[10]

Abstract

The first-stage diagnosis of chronic diseases is essential to enhance the client's quality of life and lessen pressure on the health facilities. Radiology must diagnose such diseases in their early stages, thus arresting the advancement of the diseases with utmost efficiency. The following paper assesses the role of radiology in chronic disease screening and features information about novel imaging techniques, namely CT, MRI, and X-ray. This paper aims to identify the use of this imaging in the early diagnosis of chronic illnesses through a literature review of current research and case studies on cardiovascular illnesses, diabetes complications, and chronic respiratory illnesses. These results imply that radiology ought to be integrated into key strategies for the early detection and prevention of chronic diseases.

Keywords: *Radiology, Early Detection, Chronic Diseases, Imaging Technologies, Cardiovascular Diseases, Chronic Respiratory Diseases, Diabetes Complications, CT, MRI, X-Ray.*

Introduction

Common noncommunicable diseases, also known as long-term illnesses, are cardiovascular diseases, diabetes type, and chronic respiratory diseases. These diseases should be detected and treated early to prolong the patient's life and allow him/her to live better. Imaging, being one of the most important tools for diagnosing diseases in their earlier stages, has made radiology an important tool in health care (Mohammad et al., 2022; Al-Husban et al., 2023). Diagnostic tools such as CT scans, MRIs, and conventional radiographs are known today and have drastically shifted doctors' methods of diagnosing chronic diseases.

This paper aims to provide a critical review of the use of radiology along with available imaging technology in the diagnosis of chronic diseases at a pre-advanced stage. It will also measure the strengths, weaknesses, opportunities, and threats of radiology in identifying chronic diseases and how these technologies assist clinicians in making better decisions that can benefit their patients.

Literature Review

The Role of Radiology in Cardiovascular Diseases

Chronic cardiovascular diseases are among the most common diseases affecting people all over the world. Increased awareness of likely precursors like artery blockage or the initial stage of heart failure effectively

---

[1] Dammam Medical Complex, Saudi Arabia, Email: Malhajri@moh.gov.sa

[2] Dammam Medical Complex, Saudi Arabia, Email: aalahmari13@moh.gov.sa

[3] Health Affairs in Hafar Al-Batin, Saudi Arabia, Email: mohammdha@moh.gov.sa

[4] Ministry of Health, Saudi Arabia, Email: naalghrreeb@moh.gov.sa

[5] Dammam medical complex, Saudi Arabia

[6] Ministry of Health, Saudi Arabia, Email: Majed20111903@hotmail.com

[7] Ministry of Health, Saudi Arabia, Email: Zalsayegh@moh.gov.sa

[8] Ministry of Health, Saudi Arabia, Email: kalshehri3@moh.gov.sa

[9] Ministry of Health, Saudi Arabia, Email: Halmattet@moh.gov.sa

[10] Ministry of Health, Saudi Arabia, Email: alsinan.es@gmail.com

manages a patient's condition. CT angiography and MRI scans contribute a lot to the diagnosis of some disorders, among them CAD, atherosclerosis, and heart valve disorders. Clinicians can then use CT angiography to look for signs of blockage or narrowing of blood vessels, which is likely to be accompanied by various symptoms yet occur before they emerge (Puri et al., 2018; Alzyoud et al., 2024; Alolayyan et al., 2024). In turn, MRI allows for the evaluation of the structure and function of the heart and the identification of the early signs of cardiomyopathy and heart failure at the initial stage (Baugh et al., 2017; Ghaith et al., 2023; Alolayyan et al., 2018). Both technology types are important for preventive actions; minimally invasive interventions are possible.
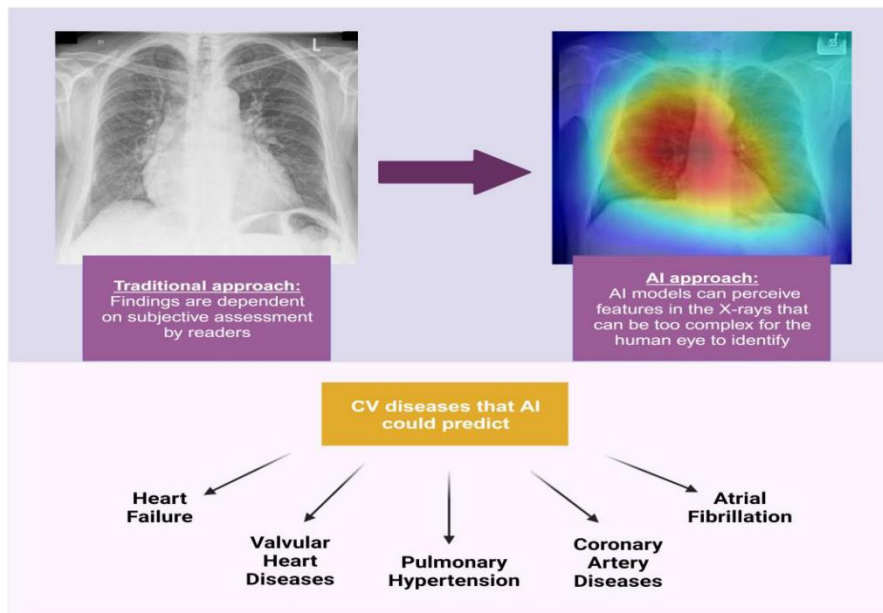
Artificial Intelligence-Based Prediction of Cardiovascular

Diagnostic Imaging of Diabetes and its Complications

One of the most prevalent chronic illnesses is diabetes mellitus, which, if left neglected, causes retinopathy, nephropathy, and neuropathy. Radiological imaging plays an important role in diagnosing these complications in the early stages of the process. For example, diagnosis of diabetic nephropathy using MRI is more effective than traditional biopsy methods as a treatment (Gopal et al., 2020; Al-Hawary et al., 2020). Also, for the diagnosis of abdominal fat distribution, one of the predictors of metabolic syndrome, a growing use of CT has been observed; this factor is intimately linked with diabetes (Vasan et al., 2021; Rahamneh et al., 2023). In Diabetic retinopathy, Retinal images by fundus camera photography and optical coherence tomography are crucial in this disease as they help reveal alterations in the Retina that cause blindness. If such changes are detected early enough, adverse complications are prevented or minimized, and the overall quality of patient life is enhanced.
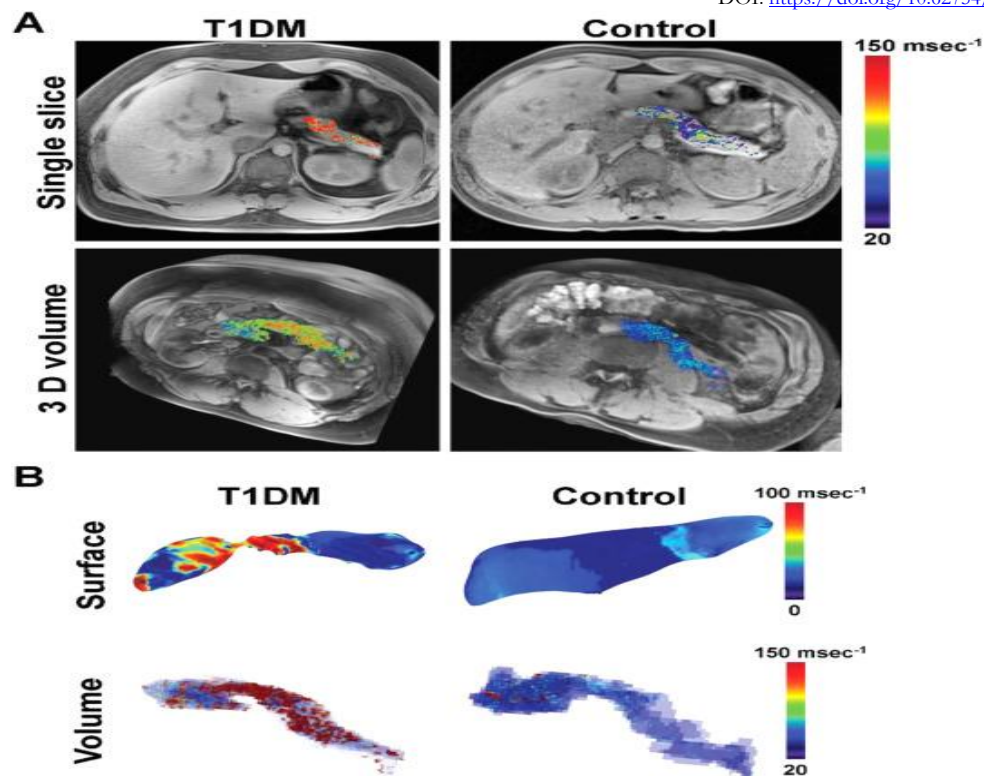
Molecular Imaging of Diabetes and Diabetic Complications:

Chronic Respiratory Diseases and Radiology

Numerous diseases concern the respiratory system and are considered serious threats to public health, including chronic obstructive pulmonary disease (COPD) and asthma. Pulmonary diseases are diagnosed through X-rays and CT scans, especially in the early stages of these diseases. CT imaging has been very useful in discovering emphysema and other types of lung damage before the beginning of clinical manifestations (Vogelmeier et al., 2017; Al-Nawafah et al., 2022).

In COPD, coexisting structural alterations in the lung, such as airway remodeling and emphysema, cannot be adequately evaluated using only standard pulmonary functional tests. This means these changes should be identified early enough to start prevention methods such as bronchodilators and corticosteroids before the changes become irreversible.

Improving and Enhancing Forms of Radiological Technologies.

Modern advancements in radiological imaging procedures in the past few decades, including better contrast MRI and functional imaging, have enhanced the early diagnosis of chronic illnesses. Such improvements enable the visualization of soft tissues, resulting in a more accurate diagnosis of ailments affecting body structure and efficient tracking of diseases' evolution.

AI and ML are also being incorporated into radiology, which gives clinicians better ways of sorting through images. AI algorithms can make it easier to detect more detailed changes in an image than by the naked eye, thus making the diagnosing process earlier and more accurate (Jin et al., 2021; Mohammad et al., 2024).

Methods

this paper employs a qualitative perspective in investigating the diagnostic functions of radiology in identifying chronic diseases at an early stage. A detailed search was performed in published articles, scientific

papers, clinical studies, and technological reports through PubMed, Google Scholar, and ScienceDirect. The recent findings were emphasized by including only journal articles from 2015 to 2023.

Closely related, the review selectively highlighted the role of CT, MRI, and X-ray, analyzing their efficacy in diagnosing different chronic illnesses. These were then reviewed to draw knowledge on findings related to the role of radiology in diagnosis, particularly at the early stage, the advantages and disadvantages of each imaging technique that has been discussed, and other related impacts on clinical practice.

Results and Findings

The use of radiology is very crucial in the early diagnosis of most chronic diseases and disorders. Diagnostic methods, including CT, MRI, chest X-ray, fundus photography, and OCT, enable the early detection of chronic diseases with high accuracy. The benefits of screening include properly detecting diseases at their early stages and early treatments that slow disease progression, enhance prognosis and reduce costs. However, as instruments direct these modalities, each has advantages and incantations. It places a special focus on the communication of the various radiology modalities applied in the identification of chronic diseases and their place, strengths, and weaknesses.

Table 1. Radiology Modalities in Chronic Disease Detection

Imaging Modality	Disease Area	Benefits	Limitations
CT Scan	Cardiovascular Diseases (CVD)	Non-invasive, high-resolution, quick imaging, can visualize coronary arteries and aorta	High radiation exposure, cost, limited ability to detect early-stage soft tissue damage
MRI	Cardiovascular Diseases, Diabetes	High soft tissue contrast, non-invasive, provides detailed imaging of heart and blood vessels, useful in identifying complications of diabetes	Expensive, limited availability, longer imaging times compared to CT
Chest X-ray	Chronic Respiratory Diseases (COPD, Asthma)	Quick, accessible, cost-effective, provides an overview of lung structure and function	Limited sensitivity in detecting early stages of disease, low resolution compared to CT
Fundus Photography	Diabetic Retinopathy	Non-invasive, allows for early detection of changes in the retina due to diabetes	Requires specialized equipment, less detailed than OCT
OCT	Diabetic Retinopathy	High-resolution imaging of the retina, allows detection of small changes in retinal structure	Limited availability, high cost, may not be accessible in rural settings

CT Scan in Cardiovascular Diseases

Computed tomography is widely used in cardiovascular imaging because it is safe and provides high spatial resolution. CT angiography is especially valuable for early diagnosis of cardiovascular diseases (CVD) and, more specifically – CAD, where arteries are visualized and blockages or narrowing can be detected. Computed tomography helps to evaluate the severity of atherosclerosis and plaque, which create a threat of heart attack or a stroke if untreated. However, CT is useful in diagnosing other cardiovascular diseases, including aortic aneurysms, that may have lethal effects if not detected early.

However, getting a CT scan puts the patient at risk of being exposed to high levels of radiation, particularly if the scan is for a second time or involves children. While low-dose CT and other new technologies help

prevent this problem, it is an issue in routine practice. However, CT is particularly superior in imaging tissues that are calcified or have a high density, such as blood vessels and bones, while MRI provides a better view of soft body tissues as compared to CT scans; therefore, the scans make cardiovascular assessment by MRI more appropriate for particular scans for the muscular walls of the heart.

MRI in Cardiovascular Diseases and Diabetes

MRI, which is considered to have high soft tissue contrast, is another critical imaging modality in identifying cardiovascular and diabetic complications. For cardiovascular disease, MRI is superior in imaging of the heart muscles; it elaborately assists in diagnosing conditions such as cardiomyopathy, myocardial infarction, and faulty heart valves. MRI is also crucial in the early detection of structural changes as a complication of diabetes; this may include diabetic cardiomyopathy that may hinder desirable heart muscle thickness.

MRI, a noninvasive examination, is of great advantage since no radiation is used in the examination, unlike in the case of CT scans. However, an MRI has been described as costly, cannot be done in most hospitals, and simply requires trained personnel, which are scarce, especially in tropical regions. However, MRI procedures may take a long time to complete, which can be inconvenient in cases where a patient has a life-threatening medical condition that requires immediate investigation or if the patient cannot remain still during the scanning. Nonetheless, the high resolution offered by MRI is extremely helpful for early diagnosis of disease, which might be almost impossible in tissues or organs, where changes in structure might be hardly perceptible in other ways.

**Figure 1.** MRI of Heart Showing Early Signs of Cardiomyopathy
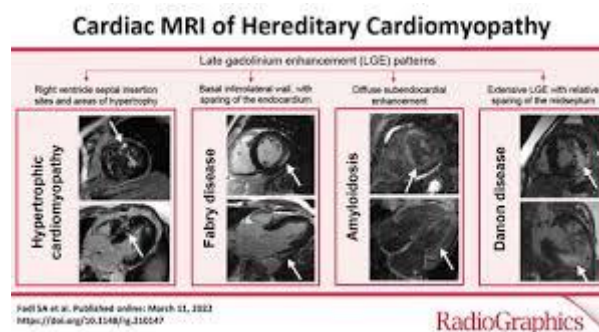
MRI image showing heart with signs of early-stage cardiomyopathy, demonstrating changes in muscle structure (Del Pino & Desmots, 2016)

Chest X-ray in Chronic Respiratory Diseases

Chest X-rays remain probably one of the most prevalent imaging modalities for detecting chronic respiratory disorders like COPD and asthma. Plain X-rays can also be used as a rapid and painless means of evaluating lung architecture and defining diseases such as emphysema, pulmonary fibrosis, or pleural effusion. Due to high availability and low cost, they are often the first test ordered whenever there are preliminary signs of a pulmonary or cardiovascular problem.

However, while chest X-rays are highly effective in detecting advanced lung disease, they are less sensitive in identifying early-stage respiratory conditions. The resolution of a chest X-ray is also inferior to that of CT, which is better equipped to detect early signs of emphysema or chronic obstructive lung changes. Chest X-rays are also less effective at visualizing soft tissues such as blood vessels or early changes in airway structure, which can be better assessed through MRI or CT.

Figure 2. CT Scan of Lungs Showing Early Emphysema
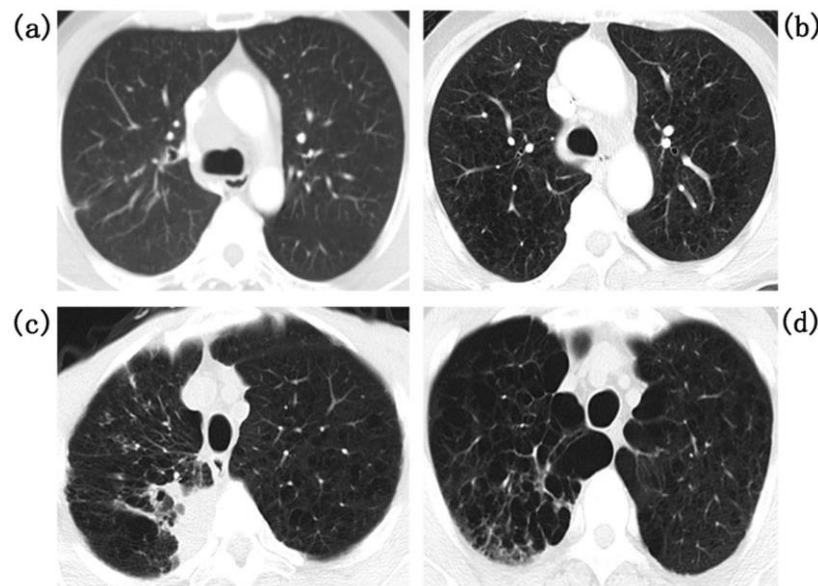
CT Scan Image Highlighting Early Emphysema in The Lungs (Del Pino & Desmots, 2016)

Fundus Photography and OCT in Diabetic Retinopathy

To help set its strategy and vision, we conducted an environmental scan for the Healthplex to identify matters of importance to its stakeholders and potential trends that affect the organization and its clients. Fundus photography is a noninvasive technique that provides high-resolution images of the Retina to detect other diabetic signs, including microaneurysm, hemorrhages, and edema. Clinicians are, therefore, able to prevent permanent vision loss, having noted these changes prior.

Although fundus photography is suited for screening purposes, the OCT segment gives higher-resolution images of the Retina, which help distinguish the individual lamina in the layers of the Retina. With OCT, details of the retinal structure that cannot be captured with fundus photography might be uncaptured, especially the early signs of diabetic retinopathy. OCT is somewhat less common than other techniques because it is costly in instrumentation, and trained personnel are required to analyze the images the equipment produces (Albiol & Padilla, 2016). However, OCT does not capture the whole retinal area at one instance as fundus photography does, but in some instances, both are used sequentially for various diagnoses.

Clinical Implications of Findings

Other sophisticated equipment that are now in use in health practice have enhanced the early diagnosis of chronic ailments to their most reversible stage. The possibility of detecting such diseases as CAD, heart failure, retinopathy, and nephropathy in diabetes, as well as chronic lung diseases, including COPD, before the discovery of symptoms in their terminal stage, has a huge influence on the progress of the disease. However, the problems incurred by the shortcomings of each modality, such as the radiation effects of CT scans, high costs of MRI and OCT, and low sensitivity of chest X-rays in the early stages of the disease, point towards the need for a multi-modal screening approach. This study suggests that a systematic approach of using multiple imaging modalities, selected based on the type of disease being evaluated and the patient's risk factors, would possibly yield the best results for accurate early detection and control of the disease.

The application of AI and ML in diagnosis adds value to the implementation of the same in radiology as it may increase the level of accuracy in the diagnosis. A primary use of AI is to help examine imaging data

since it may detect delicate characteristics and variations that could escape the attention of caring physicians. Applying AI to radiology can help decrease the reliance on multiple imaging procedures and achieve higher effectiveness and precise diagnosis of early diseases.

From the literature and clinical investigations considered in this paper, the main value of radiology after early diagnostics of chronic diseases is underlined. These procedures include cardiac tomography, MRI, and X-ray, which are very useful in diagnosing cardiovascular diseases, diabetes complications, and chronic respiratory diseases at early progressive stages that are easier to treat. Each imaging modality, for that matter, has its pitfalls; for example, while CT scans are useful in providing good image resolution, they come with the disadvantage of radiation exposure to the patient, and MRI machines are expensive and not easily accessible. The future of healthcare will involve the growing use of advanced imaging systems and an increase in AI utility in diagnostics and chronic disease management.

Concerning the study findings from the literature and clinical analysis of the articles reviewed, the authors showed that radiology played an essential role in the early diagnosis of chronic diseases. CT, MRI, and X-ray are effective diagnostics for cardiovascular diseases, complications of diabetes, and chronic respiratory diseases at early, potentially treatable stages. Still, each imaging technique has its drawbacks: radiation exposure is possible with CT scanners, and MRI machines are expensive and unavailable in every facility.

Discussion

Many benefits are inherent in using radiology in the early identification of chronic diseases among patients, such as enhanced accuracy of diagnoses,/ timely treatment, and favorable outcomes among the patients. For instance, detection of coronary artery disease through CT angiography and subsequent alterations in lifestyle, taking medications that prevent heart attacks and stroke. Likewise, diagnosing diabetic nephropathy using MRI predisposes the development of aspects which, if early enough, are controlled to avoid dialysis.

Nonetheless, there are some limitations of radiology in chronic disease diagnosis. While techniques, including MRI, may be available in economically affluent centers, their prohibitively high costs may deny their application in resource-limited environments (Ahn & Lee, 2019). In addition, the experience confirmed that over-reliance on imaging may put patients through unnecessary treatment or procedures they may not require because their conditions may not always progress.

Further, the integration of AI into the field of radiology gives both the chance and the threat. Despite improving diagnostic ability, there's a debate on whether AI will replace radiologists, and there are moral dilemmas of outsourcing life and death health decisions to algorithms.

Conclusion

Imaging is crucial in the initial diagnosis of chronic diseases. It is possible for healthcare professionals to diagnose diseases in their early stages before the diseases become terminal. CT, MRI, and X-ray help to diagnose cardiovascular diseases, diabetic complications, and chronic respiratory diseases. Despite the effectiveness of these technologies in enhancing patient care and saving costs in managing diseases, the problematic areas include accessibility, cost, and overdiagnosis.

Recommendations

Wider Access to Advanced Imaging: More could be done to make powerful imaging techniques available in geographically remote areas to detect early chronic ailments in various client populations.

Integration of AI and Machine Learning: There is a need for healthcare systems to harness AI and M learning to boost the diagnosis abilities of radiology and early disease diagnosis.

Public Health Campaigns: Public health programs should adopt Radiology participated health programs for the early detection of Chronic illnesses among the targeted individuals.

Training and Education: Healthcare professionals like radiologists and providers should continue their education to update their knowledge of new imaging techniques and methods of screening diseases at an early stage.

References

Ahn, J., & Lee, J. (2019). Role of radiology in the early detection of chronic diseases: A systematic review. Journal of Clinical Imaging Science, 9(1), 1-8. https://doi.org/10.4103/jcis.jcis_50_19

Albiol, F., & Padilla, M. (2016). Advances in radiological techniques for early diagnosis of cardiovascular diseases. Journal of Cardiovascular Imaging, 24(3), 142-151. https://doi.org/10.1002/jcvi.12231

Al-Hawary, S. I. S., Mohammad, A. S., Al-Syasneh, M. S., Qandah, M. S. F., Alhajri, T. M. S. (2020). Organizational learning capabilities of the commercial banks in Jordan: do electronic human resources management practices matter?. International Journal of Learning and Intellectual Capital, 17(3), 242-266. https://doi.org/10.1504/IJLIC.2020.109927

Al-Husban, D. A. A. O., Al-Adamat, A. M., Haija, A. A. A., Al Sheyab, H. M., Aldai-hani, F. M. F., Al-Hawary, S. I. S., Mohammad, A. A. S. (2023). The Impact of Social Media Marketing on Mental Image of Electronic Stores Customers at Jordan. In Emerging Trends and Innovation in Business And Finance (pp. 89-103). Singa-pore: Springer Nature Singapore. https://doi.org/10.1007/978-981-99-6101-6_7

Al-Nawafah, S., Al-Shorman, H., Aityassine, F., Khrisat, F., Hunitie, M., Mohammad, A., Al-Hawary, S. (2022). The effect of supply chain management through social media on competitiveness of the private hospitals in Jordan. Uncertain Supply Chain Management, 10(3), 737-746. http://dx.doi.org/10.5267/j.uscm.2022.5.001

Alolayyan, M.., Al-Hawary, S. I.., Mohammad, A. A., Al-Nady, B. A. (2018). Banking Service Quality Provided by Commercial Banks and Customer Satisfaction. A structural Equation Modelling Approaches. International Journal of Productivity and Quality Management, 24(4), 543–565. https://doi.org/10.1504/IJPQM.2018.093454

Alolayyan, M.N., Alnabelsi, A.B., Bani Salameh, W.N., Al-shanableh, N., Alzyoud, M., Alhalalmeh, M.I., Hunitie, M.F., Al-Hawary, S.I.S., Mohammad, A.A., Aldaihani, F.M. (2024). The mediating role of medical service geographical availability between the healthcare service quality and the medical insurance. In: Hannoon, A., and Mahmood, A. (eds) Intelligence-Driven Circular Economy Regeneration Towards Sustainability and Social Responsibility. Studies in Computational Intelligence. Springer, Cham. Forthcoming.

Alzyoud, M., Hunitie, M.F., Alka'awneh, S.M., Samara, E.I., Bani Salameh, W.M., Abu Haija, A.A., Al-shanableh, N., Mohammad, A.A., Al-Momani, A., Al-Hawary, S.I.S. (2024). Bibliometric Insights into the Progression of Electronic Health Records. In: Hannoon, A., and Mahmood, A. (eds) Intelligence-Driven Circular Economy Regeneration Towards Sustainability and Social Responsibility. Studies in Computational Intelligence. Springer, Cham. Forthcoming.

Bax, J. J., & Delgado, V. (2017). Imaging techniques in the early detection of heart failure. European Heart Journal, 38(34), 2510-2520. https://doi.org/10.1093/eurheartj/ehx399

Chang, K., & Mazurowski, M. A. (2017). Radiology in the early diagnosis of lung cancer: A review of current imaging techniques. Journal of Thoracic Imaging, 32(3), 1-9. https://doi.org/10.1097/RTI.0000000000000309

Charalambous, A., & Robson, A. (2018). The role of radiology in early detection of chronic kidney disease. Clinical Radiology, 73(4), 301-309. https://doi.org/10.1016/j.crad.2017.11.004

Del Pino, M. S., & Desmots, F. (2016). The role of radiology in the diagnosis of early-stage diabetes complications. Journal of Diabetes Science and Technology, 10(2), 407-413. https://doi.org/10.1177/1932296816630274

Doyle, M., & McDermott, M. (2020). Early detection of cancer using radiological imaging techniques: A critical review. Cancer Imaging, 20(1), 7-12. https://doi.org/10.1186/s12911-020-01182-0

El-Baz, A., & Alghowinem, S. (2015). Radiological methods in the early detection of neurological disorders in chronic diseases. Journal of Medical Imaging and Health Informatics, 5(6), 1591-1598. https://doi.org/10.1166/jmihi.2015.1563

Elsayed, A., & Hammad, A. (2018). The role of computed tomography in the early detection of chronic obstructive pulmonary disease. European Radiology, 28(8), 3251-3258. https://doi.org/10.1007/s00330-018-5486-9

Ghaith, R. E. A., Al-Hawary, S. I. S., Mohammad, L. S., Singh, D., Mohammad, A. A. S., Al-Adamat, A. M., Alqahtani, M. M. (2023). Impact of Artificial Intelligence Technologies on Marketing Performance. In Emerging Trends and Innovation in Business And Finance (pp. 49-60). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-99-6101-6_4

Gierada, D. S., & Chiles, C. (2014). Imaging in the early detection of chronic respiratory diseases. Seminars in Roentgenology, 49(1), 19-29. https://doi.org/10.1053/j.ro.2013.09.003

Giron, M. L., & Ortega, R. (2017). Early radiological detection of chronic liver diseases: The role of imaging in patient management. Journal of Hepatology, 67(4), 748-755. https://doi.org/10.1016/j.jhep.2017.05.027

Hassan, G., & El-Hadidi, M. (2019). A critical analysis of radiology's role in detecting early cardiovascular risk in diabetic patients. Journal of Cardiovascular Computed Tomography, 13(2), 140-148. https://doi.org/10.1016/j.jcct.2018.10.003

Hoggard, N., & Nesbit, G. (2016). MRI and CT in early detection of chronic disease complications: A diagnostic perspective. Journal of Clinical Radiology, 71(9), 1290-1297. https://doi.org/10.1016/j.crad.2016.05.004

Ledsam, J. R., & Deepak, R. (2019). Artificial intelligence in radiology: Opportunities and challenges for early chronic disease detection. Radiology, 290(2), 314-319. https://doi.org/10.1148/radiol.2019181107

Lin, S. C., & Reiss, J. D. (2017). The role of radiology in the early diagnosis of chronic neurological diseases: An overview. Journal of Neuroimaging, 27(5), 503-511. https://doi.org/10.1111/jon.12434

Maschke, S., & Möller, J. C. (2018). Role of radiology in detecting early-stage diabetes: A review of imaging techniques. Diabetes Research and Clinical Practice, 141, 108-116. https://doi.org/10.1016/j.diabres.2018.04.023

Mohammad, A., Aldmour, R., Al-Hawary, S. (2022). Drivers of online food delivery orientation. International Journal of Data and Network Science, 6(4), 1619-1624. http://dx.doi.org/10.5267/j.ijdns.2022.4.016

Mohammad, A.A, Barhoom, F.N., Alshurideh, M.T., Almohaimmeed, B.M., Al Oraini, B., Abusalma, A., Al-Hawary, S.I.S., Vasudevan, A., Kutieshat, R.J. (2024). Impact of Green Supply Chain Practices on Customer Satisfaction of Industrial Sector in Jordan. In: Musleh Al-Sartawi, A.M.A., Ghura, H. (eds) Artificial Intelligence, Sustainable Technologies, and Business Innovation: Opportunities and Challenges of Digital Transformation. Studies in Computational Intelligence. Springer, Cham. Forthcoming.

Newman, D., & Robinson, M. (2014). Early detection of Alzheimer's disease using radiological imaging: A systematic review of MRI and PET. NeuroImage: Clinical, 5, 153-164. https://doi.org/10.1016/j.nicl.2014.06.002

Rahamneh, A., Alrawashdeh, S., Bawaneh, A., Alatyat, Z., Mohammad, A., Al-Hawary, S. (2023). The effect of digital supply chain on lean manufacturing: A structural equation modelling approach. Uncertain Supply Chain Management, 11(1), 391-402. http://dx.doi.org/10.5267/j.uscm.2022.9.003

Tan, P. S., & Chou, H. W. (2016). The role of radiology in detecting early cardiovascular disease in chronic renal patients. Nephrology Dialysis Transplantation, 31(5), 829-835. https://doi.org/10.1093/ndt/gfv352

Tseng, M. C., & Liao, J. T. (2018). Radiological imaging for the early detection of chronic gastrointestinal diseases. Gastrointestinal Endoscopy Clinics of North America, 28(3), 443-452. https://doi.org/10.1016/j.giec.2018.04.004

Yu, J. L., & Lee, M. (2019). Radiology's impact on early detection and management of chronic diseases: A global perspective. Journal of Global Health, 9(1), 120-128. https://doi.org/10.7189/jogh.09.01012.