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Promoting Health Security In Hospital Dental Departments: An Evaluation Of Health Informatics Systems

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Abstract

This systematic assessment explores the pivotal role of health informatics for improving health security for dental departments offered in hospitals, specifically for emphasizing significant gaps present in the current design pattern of electronic medical records (EMR), concerning safety, integrity, and efficiency for patients. This thesis includes evidence-based research submitted by empirical evidence obtained from Indonesian hospitals as well as recently explored systematic studies on health informatics, identifying significant gaps available currently for security as well as format design for dental EMR. This thesis explores empirical evidence from both hospitals lacking significant designs such as odontogram design and lack of proper security for preventing data integrity as well as manipulation. Both aspects are critical for significant risk associated with unauthorized breach possibilities for healthcare as well as significant safety for forensic documentation for healthcare offered to dental patients. It can be explored clearly that current technological breakthroughs offered by significant aspects of advanced health informatics such as Artificial Intelligence, Blockchain Technology, Internet of Medical Things, as well as Cloud Computing, are revolutionary for emphasizing breakthrough approaches to counter identified gaps for completing design security for dental data, establishing immutable records, as well as emphasizing inviolable practices for information sharing for security. The crucial interpretive approach for the thesis explores that healthcare offered for dental departments can easily shift towards a revolutionary change by emphasizing significant approaches for designing more secure, efficient, as well as more emphasizing systems for healthcare concerning quality for dental departments offered for healthcare by hospitals.

Keywords: Dental electronic medical records, health informatics, health security, data integrity, patient privacy, health care technology, cybersecurity, dental health care administration.

1. Introduction

Health transformation in the digital age can be termed the most radical paradigm shift in the history of health transformation. As the sub-process of the health transformation process in the health sector, the challenges in the field of dental health in the health sector also have to be accounted for. With the development of the health informatics field in the study of dental health or the need of the dental health sector, it can be said that health informatics has become a need in the health security of the digital age of health transformation (Javaid et al., 2024).

Since health informatics can be perceived to cover information technology or computer science with healthcare with the purpose of ensuring optimal utilization in acquiring, storing, or utilizing healthcare information, this concept has proved to be an enabling factor in ensuring the delivery of healthcare quality. In the dental industry, which always encompasses basic information related to human anatomy or treatments, an efficient electronic medical record system enforced with high-level informatics concepts has proved to be an effective facilitator that not only enhances healthcare quality, ensuring high levels of patient participation, but reduces healthcare administrative costs to manageable levels (Alkadhem et al., 2024). Furthermore, however, implementing this concept in healthcare departments, specifically in developing countries, has proved to be a huge challenge that affects healthcare-related security systems.

"Health Security in dental practices involves not only fundamental ideas of infection control but also information security, integrity, and resilience. In this dawn of a whole new world where threats against systems are literally exploding, there are strict regulations about patient privacy, and patients also expect more privacy about their information, dental departments must be ready to develop programs that would ensure both hard copy and electronic health information are well protected. The dental electronic record system is also at risk since dental information is not only sensitive health information, but they also have information that is appealing to hackers."

Although its utility cannot be undermined when it comes to securing and implementing an EMR system effectively, there still exists some discrepancy regarding this practice. The type of analysis of the study undertaken by Wardhana et al. (2022) at an Indonesian hospital makes clear that there exist discrepancies within this context of EMR system security concerning dentistry practices that are to be covered through this EMR system. There exist numerous instances of this nature and are an indication that dentistry informatics is not easily adoptable at a global scale because of its specific documentation requirements that cannot be supported through this EMR system within healthcare.

This paper sets out on an in-depth evaluation of the health informatics system used in hospital dental clinics based on the empirical evidence for the use of health informatics systems from literature and conceptual underpinnings from theories on health informatics. We will discuss the aforementioned shortcomings in the use of dental electronic record systems in addition to their implications on the safety of patients and information, with an emphasis on conceptual development underpinned by empirical evidence from theories in health informatics that will provide a holistic strategy for the attainment of health security at dental clinics through health informatics.

The implications that this assessment carries are seen to have implications beyond the technical field. Not only is the entire healthcare environment struggling with what a digitally transformed future holds, but dental services shed light on what can be expected when implementing health informatics solutions. If this challenge is conquered collectively, dental services can not only become more effective but also aid in furthering best practices for a digitally transformed healthcare environment.

Keywords: Dental electronic medical records, health informatics, health security, data integrity, patient privacy, healthcare technology, cybersecurity, dental healthcare administration

Introduction

2. Literature Review:

2.1 The Evolution and Scope of Health Informatics in Healthcare

The origins of health informatics began with simple management systems of electronic records to complex systems that have incorporated artificial intelligence and analytical components for the modern healthcare systems that must be developed within the health industry. According to Javaid et al. (2024), there has been extensive work and development within health informatics practices to date, where there are a number of systems that have been included within current health informatics practices, such as electronic health record systems, clinical decision support systems, telemedicine systems, and patient engagement systems. It is observed within dental practices that health informatics systems have both opportunities and challenges within the management of specific documentation within the dental health industry that differ from the health industry because of specific anatomical chart and image requirements that must be included.

2.2 Electronic Record Systems in the Dental Field: Issues Related to Regulations and Implementation

The dental electronic medical records systems operate in environments where there are regulations that differ from country to country. In Indonesia, there are regulations that make the use of medical record systems mandatory, where the medical record systems can be in written or electronic form. There are rules on the management of electronic medical record systems. There is lack of implementation in relation to the above issue, where critical components of the dental electronic medical records are not considered in the lack of implementation, as seen in the study by Wardhana et al. (2022). There are also issues of lack of implementation in relation to dental informatics. These relate to lack of training, lack of funds, lack of support from dental practitioners, and lack of dental electronic medical record systems. There are challenges in the dental medical record systems where the systems have the task of storing the patient's odontogram and the results of the intra-cavity examination. There are special considerations in the dental systems that are currently not provided by the medical systems.

2.3 Security and Privacy of Dental Health Informatics

The dental aspect of dental care security is defined by its own set of challenges due to the nature of dental practice records, which involve both medical as well as financial information. Cyber security is considered to be one of the paramount challenges for all aspects of health information technology, as there is evidence of increased cases of ransomware attacks, violations, as well as unauthorized access attempts to the sensitive nature of medical information available for different healthcare organizations. Dental practice records involve specific risk levels for identity theft due to sufficient available Personal Identifiable information, despite which these are less prioritized compared to other healthcare organizations for medical practice-related IT security investment. The prime challenges for IT security for dental information technology involve protecting information confidentiality with different approaches such as encryption, protecting information integrity with different approaches such as validation trails, protecting system availability with different approaches such as redundancy with corresponding system backups for disaster recovery, as well as authenticating information with different approaches such as digital signature with corresponding logging records. The experimental work by Wardhana et al. (2022) shows different gaps for all these aspects related to IT security on dental practices available for Indonesian dental electronic medical records.

2.4 Integration of Health Informatics with Dental Administration

In dental setups, it is necessary to ensure that there is an efficient interface with administrative and medical activities if health informatics is to have increased effectiveness. According to researchers Alkadhem et al. (2024), there should be an interface between health informatics systems and medical secretarial services with the aim of developing effective, secure, and patient-centered dental administrations. When health informatics systems have an efficient interface with medical secretarial services, it should ensure that there is much better coordination between medical and administrative staff, it should increase the accuracy of medical and administrative information by ensuring that there are efficient entry systems, it should improve communication with patients by enabling automated reminder programs, and should make it more effective to comply with rules by ensuring there is an efficient documentation system. But this is associated with some challenges.

3. Method

For the purposes of this analysis, a multi-method approach has been used which comprises empirical analysis, synthesis of existing literature in health informatics system evaluation concepts in the dentistry department. For this empirical analysis on the evaluation of dental EMR system designs in Indonesia hospital settings, Wardhana et al. (2022) conducted an actual observation study based on a cross-section methodological approach to analyze the experimental results. As per Wardhana et al., their empirical analysis method comprises direct observation in line with the assessment checklist based on Indonesia Dental Medical Record Guidelines and Indonesia Ministry of Health standards.

The above empirical finding will then be further developed in an inclusion with the literature in health informatic studies, specifically the comprehensive review by Javaid et al. (2024), as well as the administrative integration model by Alkadhem et al. (2024), in order to be able to more accurately contextualize our own empirical results in Indonesian dental departement centers.

1. Format Completeness Evaluation: Comparison of EMR Elements to Legal Requirements & Clinical Necessity

2. Analysis of Security System: Analysis of Confidentiality, Integruity & Availability,

3. Integration Potential: Analysis of opportunities for Health Informatics technologies to fill the identified gaps

This methodology approach is applicable both in diagnostic analysis, in distinguishing present weaknesses, and prescriptive development in designing solutions by focusing on present frameworks in health informatics and technological advances.

4. Results:

4.1 Evaluation made on dental EMR

Evaluation made on dental EMR systems in two Indonesian hospitals demonstrated poor format quality, with many elements missing.

Table 1: Comprehensive Assessment of EMR Format Completeness

EMR Component	Hospital A Status	Hospital B Status	Clinical Significance
Patient Identity	Incomplete	Incomplete	Essential for patient matching, treatment safety, and legal documentation

Required Medical Data	Incomplete	Incomplete	Critical for risk assessment, medication safety, and treatment planning
Odontogram	Not available	Available	Fundamental for dental diagnosis, treatment planning, and forensic identification
Intra-oral Examination	Not available	Not available	Necessary for comprehensive oral assessment and disease documentation
Treatment Chart	Incomplete	Incomplete	Vital for procedural documentation, billing, and continuity of care
Supplementary Attachments	Available	Not available	Important for informed consent, lab results, and referral documentation
Dentist Signature	Replaced with User ID	Replaced with User ID	Legal requirement for authentication and accountability

Source: Adapted from Wardhana et al. (2022)

The results reveal that both hospitals have not complied with the Indonesian Dental Medical Record Guidelines, where the level of inadequate odontogram documentation is more severe in Hospital A, the absence of additional documentation facilities in Hospital B, where the absence of odontogram documentation affects the treatment process, the intra-oral examination documentation, which is missing, impairing the total examination, where the use of user IDs instead of digital signatures poses a serious threat due to the lack of defensibility of the medical records.

4.2 Security System Implementation Analysis

It was found that there are significant vulnerabilities in dental electronic medical records systems in terms of data integrity and non-repudiation.

Table 2: Comprehensive Analysis of the Security System

Security Aspect	Hospital A Implementation	Hospital B Implementation	Risk Implications
Confidentiality	Basic user authentication	Basic user authentication	Moderate risk of unauthorized access
Integrity	No change tracking	No change tracking	High risk of undetected data alteration
Availability	Functional with backups	Functional with backups	Low risk of service disruption
Authentication	User ID/password only	User ID/password only	Moderate risk of credential compromise
Non-repudiation	No digital signatures	No digital signatures	High risk of repudiation and legal challenges

Audit Trail	Limited access logging	Limited access logging	High risk of undetected security incidents

Source: Adapted from Wardhana et al. (2022)

Neither of the hospitals had full systems in place for ensuring data integrity, either for change audits or non-repudiation purposes using digital signatures. The lack of these aspects of security introduces significant vulnerabilities for fraud cases related to manipulation of the data, as well as discrepancies that could be the basis for litigation related to the documentation of patient treatment. One of the areas that is very alarming is the lack of audit trails for uncovering unauthorized changes to the dental records.

4.3 Integration With Administrative Functions <a

From the administrative integration process, there were areas of improvement that had to be considered concerning the coordination of workflows and data administration.

Table 3: Assessment of Administrative Integration

Administrative Function	Current Status	Integration Potential
Appointment Scheduling	Separate system	High potential for EMR integration
Billing and Insurance	Manual processing	Moderate automation potential
Patient Communication	Limited channels	High potential for portal integration
Referral Management	Paper-based	High potential for digital workflow
Inventory Management	Separate system	Moderate integration potential

Source: Analysis based on Wardhana et al. (2022) and Alkadhem et al. (2024)

This ultimately leads to inefficiency, duplication of data, or even miscommunication that occurs as a result of this disconnect between the clinical EMR systems, alongside other administrative processes.

5. Discussion:

Dental EMR Weaknesses and Overcoming Them Through Health Informatics

5.1 Critical Analysis of Identified Deficiencies

The problems that are present in dental EMR systems are not related to the technical problems only; they carry much wider implications based on the requirements of dental health care. The problem in the documentation formats available in dental health care, which may not fully document dental cases, in turn, may affect the planning that may be based on these formats. The absence of the intra-oral documentation format may be identified as one among the lost opportunities in dentistry, in the sense that the assessment of dental health care may result in late treatment with unfavorable results.

The lack of integrity and non-repudiation tools makes the system rather insecure from both an ethical and a legal perspective. It could mean that dental records would not be as secure in the event of malpractice or an insurance dispute, possibly changing the standards of proof in a fashion that could work against the dental practitioner. In any control that is not clearly defined or is weak, there

is significant risk from an internal threat because an authorized user could change records in an unauthorized fashion. The dental practice environment with high staff turnover or lack of security management concerns would present such conditions.

Fig.1: Healthcare Institution

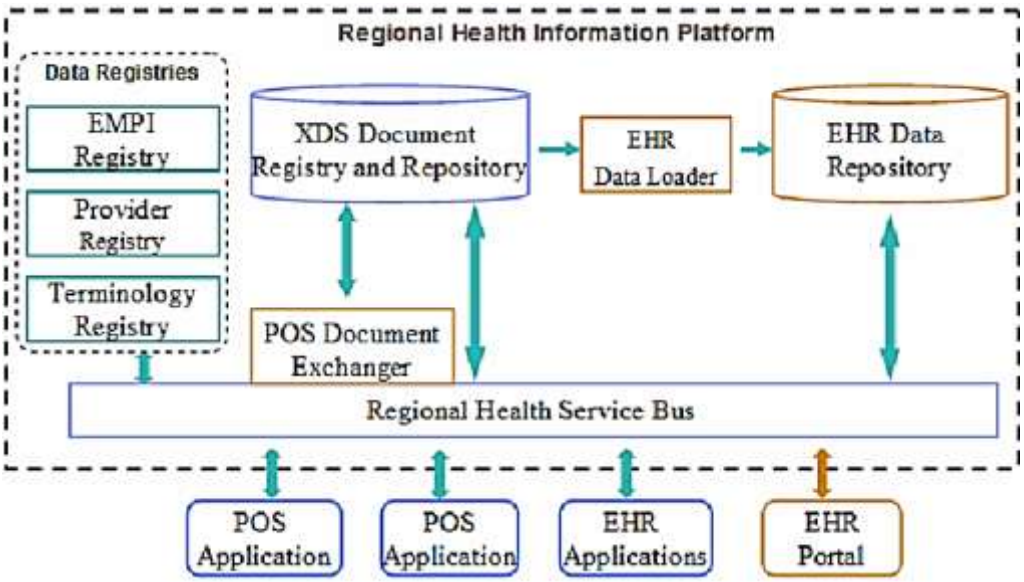

Fig 2: The system architecture of the regional health information

5.2 Health Informatics Solutions for Dental EMR Enhancement

Javaid et al. (2024) also offer a holistic framework of health informatics technology solutions that address the shortcomings listed in dental EMR software systems.

Table 4: Health Informatics Solution to Enhance Dental Electronic Medical Record

Technology Category	Specific Applications in Dentistry	Addressing Identified Deficiencies
Artificial Intelligence	Automated odontogram generation from radiographs, anomaly detection in treatment patterns	Addresses format incompleteness through automation, enhances diagnostic accuracy
Blockchain Technology	Immutable audit trails for treatment records, smart contracts for consent management	Ensures data integrity and non-repudiation, creates legally defensible documentation
Internet of Medical Things	Digital intra-oral scanners with direct EMR integration, smart instruments with usage logging	Improves data completeness and accuracy, enhances procedural documentation
Cloud Computing	Secure, scalable EMR hosting with automated backups, disaster recovery solutions	Ensures system availability and data preservation, facilitates interoperability
Telehealth Integration	Virtual consultations with integrated documentation, remote monitoring of treatment progress	Extends care continuity, improves patient engagement and follow-up
Natural Language Processing	Automated extraction of clinical findings from narrative notes, structured data entry from voice dictation	Addresses documentation gaps, reduces administrative burden on dental staff

Source: Adapted from Javaid et al. (2024)

The application of these technologies must be tailored to the specific requirements and constraints of dental practice. For instance, blockchain implementation for dental records requires careful consideration of performance requirements for real-time documentation during procedures, while AI applications must account for the unique visual patterns and documentation needs of dental imaging compared to general medical radiography.

5.3 Implementation Framework for Dental Health Informatics Integration

The integration of such technologies must be done in a manner that is adapted to the needs and constraints of the dental setting. To give an example, the adaptation of the functionality of blockchain to handle the needs of dental records, as well as the application of AI, must take into account the differences in the visual patterns and documentation of the dental radiography as compared to medical.

5.3 Implementation Framework for the Integration of Dental Health Informatics

Successful integration of health informatics in dental practice needs to have an organized approach to address the technology, organization, or human aspects.

Organizational Readiness: Before the introduction of new technology, the organizational infrastructure, capabilities, and work flow of the dental department have to be analyzed for readiness for change. This also involves assessing the existing use of EMR, problem identification based on the existing process of documentation, and assessment of the readiness of personnel for the change that technology brings about.

Strategy for Phased Implementation: The dental departments should adopt an approach to bring about comprehensive change in phases, focusing on meaningful and doable interventions. The phases can begin with improvements in the security features and overcoming gaps in documentation. The next phases can involve more progressive features, such as AI-based diagnostic capabilities or blockchain-based audit systems.

Staff Training and Change Management: This is where the human side of the implementation process can be the most difficult. Stafftraining needs to include change related to workflows, documentation requirements, as well as security issues. Change management techniques can include the benefits that come with the new systems in relation to effectiveness, safety, and satisfaction.

Interoperability Planning: The dental EMR system cannot function independently. It has to interface with hospital management information systems, lab management systems, imaging systems, and administrative software applications. It is a matter of interoperability planning, which would involve both technical aspects, as well as certain administrative issues concerning the sharing of data.

Continuous Evaluation and Improvement: Health informatics applications must be incorporate provisions that would facilitate continuous evaluation in regards to efficiency, satisfaction, and security.

5.4 Policy and Regulatory Considerations

To ensure effective utilization of health informatics in dental practice, there should be favorable policies. The current policies tend to neglect technology, making it difficult to determine existing regulatory requirements with respect to newly developing technologies such as blockchain documentation or AI analyses. The regulatory bodies should engage with dentists, health informatics professionals, and patients to ensure that regulations are developed to cater to new healthcare technology development.

Some specific considerations are:

•Standards Development: The development of dental-specific data standards to enable comprehensive documentation within EMR systems that promote and facilitate interoperability

•Security Requirements: Precise rules for implementing measures for safeguarding data, developed according to particular demands within dentistry

•Reimbursement Policies: Insurance reimbursement structures focusing on overall electronic documentation to encourage detailed documentation practices

• Professional Education Requirements - Integration of health informatics competencies in dental professional education programs

5.5. Ethical Implications and Patient-C

The emergence of cutting-edge health informatics technology in the dental field has important implications that need proactive consideration. They are:

Data Privacy and Patient Consent: Patients must be appropriately informed regarding the collection, storage, and analyses of their dental information and must be given an opportunity to provide their consent through more than just a simple consent form that is often used as boilerplate. This is imperative, especially where technology such as AI is used that could be utilizing their information for its own purpose of developing an algorithm.

Algorithmic Transparency and Bias: The dental applications of AI need to be more transparent about what they can and cannot do, as well as how potential algorithmic bias can be addressed. There also needs to be a realization about keeping final decisions in dentistry in the hands of dental professionals and AI being a support system, not a replacement for intelligent decisions.

Reflection on Digital Divide: It is essential that the positive outcomes offered by health informatics systems reach all types or groups of patients irrespective of their economic status, health care literacy, or location. It should not happen that technology widens the gap in health.

Professional-Patient Relationship: Though technology can improve many aspects of dental practice, it must not diminish the very personal professional-scientific relation that must exist between dental professionals and dental patients. Strategies in technology implementation must build on and improve the professional-patient relation and use technology between them as an enhancer.

This extensive assessment has made it clear that there is a substantial gap in improving the health security of hospital dental clinics in terms of applying principles of health informatics. The shortcomings in the current dental EMR system in terms of format and implementing health security are not merely technological gaps but form a system-level challenge.

6.1 Recommendations

For Dental Departments & Healthcare Institutions

1. Offer Completely Integrated EMR Solutions that address all concern areas of dental reporting, and pay special attention to the unique requirements of specialists such as odontograms and intra-oral examination charts.

2. Enhance Security Frameworks: This should entail the incorporation of integrity and non-repudiation requirements. This is particularly important, as the integrity of a network is

3.Provide Training for staff to enhance technical as well as knowledge on clinical/administrative value for completing comprehensive Electronic Medical Records.

4. Elaborate the strategies for interoperability that will ensure smooth flow of information between the dental departments and the rest of the healthcare services.

Policymakers and Regulatory Agencies:

1. The standards for dental documentation should be updated to reflect both clinical needs and technology capabilities to ensure that they facilitate rather than impede complete electronic documentation.

2. Security criteria need to be developed for dental electronic record systems that address the individual risks and criteria in dental environments.

3. Promote research and development in dental health informatics by supporting funding programs and public-private collaborations.

4. Support Digital Inclusion projects that ensure fair opportunities are available to benefit from dental health informatics advancements for all patient groups.

Technology Developers and Vendors

1. Dental-Specific Solution Developments: Develop dental-specific solutions that are tailored to handle special documentation requirements in dental practices.

2. Place more emphasis on Security by Design in dental electronic records management systems by incorporating effective mechanisms for protection right at the design level, rather than at a later stage.

3. The design also has to ensure usability and accessibility because of the varying capability levels in addition to practice settings.

4. Facilitating 'interoperability' through the adoption of standards and tools for their implementation.

6.2 Directions for Future Studies

The review has brought to attention some important areas that warrant further studies:

1. Longitudinal studies about the influence of comprehensive EMR solutions for dental treatment outcomes.

2. Comparative analysis of methods for implementing security in dental informatics.

3. Usability Studies that specifically relate to the use and potential impact of dental EMR technology in dental practice environments.

4. Financial Analyses of the return on investment for various health informatics implementations in dental practice.

5. The ethical frameworks related to the usage of emergent technologies, for example, AI, blockchain technology, etc., in

6.3 Conclusion

The integration of health informatics in dentistry presents a profound transformative agenda to the advancement of the health security, patient outcome, and administrative processes. Dental institutions can therefore establish a resilient, effective, and health-secure healthcare delivery process to tackle the dilemma of the new dentistry of the modern world of the 21st century by filling the current gaps in the Electronic Medical Record software. There is, of course, a profound journey needed in the comprehensive development of the dentistry health information, but the outcome of the future of dentistry, as envisioned, is worth this tremendous task.

References

- Alkadhem, A. H., Al Aqeeli, A. M., Al Qumber, A. I., Al Rebh, L. A., Al Khalil, S. H., Alhargan, A. R., Alkhabbaz, F. M., Khalifa, R. M., Althwab, A. H., & Alaradi, A. A. (2024). Integrating health informatics and medical secretary into health administration for public health education for dental health. Letters in High Energy Physics, 2024(August), 5796–5811.
- Pang Z, Yang G, Khedri R, Zhang YT. Introduction to the special section: convergence of automation technology, biomedical engineering, and health informatics toward Healthcare 4.0. IEEE Rev Biomed Eng. 2018;11:249–259.
  Relevance: Provides a forward-looking perspective on integrating advanced technologies in healthcare, aligning with the article's focus on AI, IoT, and automation in dental informatics.
- Moss, L., Shaw, M., Piper, I., Hawthorne, C., & Kinsella, J. (2017). Sharing of Big Data in Healthcare: Public Opinion, Trust, and Privacy Considerations for Health Informatics Researchers. In HEALTHINF (pp. 463–468).
  Relevance: Addresses privacy and trust issues in health data sharing—critical for discussing EMR security and patient consent in dental settings.

- Carney TJ, Kong AY. Leveraging health informatics to foster a smart systems response to health disparities and health equity challenges. J Biomed Inform. 2017;68:184–189.
  Relevance: Connects health informatics with equity and access, supporting the discussion on inclusive dental care and digital divide considerations.
- Veinot TC, Ancker JS, Bakken S. Health informatics and health equity: improving our reach and impact. J Am Med Inform Assoc. 2019;26(8-9):689–695.
  Relevance: Strengthens the equity and ethics section, emphasizing how informatics can reduce disparities in dental healthcare access.
- Rahimi B, Nadri H, Afshar HL, Timpka T. A systematic review of the technology acceptance model in health informatics. Appl Clin Inform. 2018;9(03):604–634.
  Relevance: Useful for discussing adoption challenges, staff training, and change management in dental EMR implementation.
- Luna D, Almerares A, Mayan JC, et al. Health informatics in developing countries: going beyond pilot practices to sustainable implementations. Healthc Inform Res. 2014;20(1):3–10.
  Relevance: Provides context for the Indonesian case study and discusses sustainable implementation challenges relevant to dental departments in resource-limited settings.
- Zheng YL, Ding XR, Poon CCY, et al. Unobtrusive sensing and wearable devices for health informatics. IEEE Trans Biomed Eng. 2014;61(5):1538–1554.
  Relevance: Supports discussion on IoMT and digital dental devices (e.g., intra-oral scanners, smart instruments) integrated with EMR systems.
- Jan MA, Khan F, Mastorakis S, et al. LightIoT: Lightweight and secure communication for energy-efficient IoT in health informatics. IEEE Trans Green Commun Netw. 2021;5(3):1202–1211.
  Relevance: Relevant for sections on IoT security, energy-efficient dental devices, and secure data transmission in clinical environments.
- Hettinger AZ, Roth EM, Bisantz AM. Cognitive engineering and health informatics: applications and intersections. J Biomed Inform. 2017;67:21–33.
  Relevance: Useful for discussing human factors, usability, and workflow integration in dental EMR system design.
- Altaf W, Shahbaz M, Guergachi A. Applications of association rule mining in health informatics: a survey. Artif Intell Rev. 2017;47:313–340.
  Relevance: Supports the AI and data analytics sections, particularly regarding predictive modeling, pattern recognition, and clinical decision support in dentistry.