UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Facultad de Administración y Dirección de Empresas /UPV

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

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Analyzing and Evaluating Existing Dental Practice Management Software: A Comprehensive Study to Identify Gaps and Opportunities for Improvement

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AUTHOR: Kharchenko, Bohdan

Tutor: González Ladrón de Guevara, Fernando Raimundo

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TRABAJO DE FIN DE MÁSTER EN GESTIÓN DE EMPRESAS, PRODUCTOS Y SERVICIOS

ANALYZING AND EVALUATING EXISTING DENTAL PRACTICE MANAGEMENT SOFTWARE: A COMPREHENSIVE STUDY TO IDENTIFY GAPS AND OPPORTUNITIES FOR IMPROVEMENT

AUTOR: KHARCHENKO, BOHDAN
TUTOR: GONZÁLEZ LADRÓN DE GUEVARA, FERNANDO RAIMUNDO

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1. INTRODUCTION

1.1. Introduction to the problem

The modern world is defined by the rapid development of information technologies, which actively affect various fields of human activity, including medicine. Dental practice, as an essential component of the healthcare industry, also feels the influence of this process. Advances in modern technologies open up new opportunities for dentists to manage practice, ensure work efficiency, and improve the quality of medical services. One of the tools that help to achieve these goals is dental practice management software.

The need to organize and optimize work processes in dental clinics and offices is due to several problems that may arise due to the lack of clear and effective practice management. One of these issues is the insufficient use of information technologies for accounting and analysis of work processes. Traditional medical and patient records maintenance methods can lead to irreversible errors and loss of time and resources.

Given the rapid development of modern technologies, the problem of choosing and implementing effective software for dental clinics arises. Existing solutions may not meet the needs of dental practitioners, may not be flexible enough, and may not provide a full range of practice management features. An important aspect is also the analysis and consideration of the requirements of legislation and standards regarding the processing of medical information, ensuring the confidentiality and security of patient data.

The relevance of this topic lies in the need to improve the quality and efficiency of dental services, ensure convenience for patients, and revise the working conditions of medical professionals. The implementation of modern information technologies and software can help automate routine tasks, create better interactions with patients, reduce the risk of errors, and promote the development of management processes in dental practices.

Modern technologies provide unique opportunities for reworking the processes of providing medical services, ensuring safety and efficiency. This study aims to analyze existing software

solutions and identify their shortcomings and potential opportunities for improvement, which, as a result, can contribute to improving the activities of dental practices and increasing the quality of providing services to patients. The research aims to identify the advantages and disadvantages of various software solutions, as well as to develop recommendations on the optimal ways to improve them.

Based on the overview, the problem for the thesis was identified: “Analyzing and Evaluating Existing Dental Practice Management Software: A Comprehensive Study to Identify Gaps and Opportunities for Improvement”. The study includes the following chapters.

Literature review.

The meaning of management systems and software, their structure, functions, and use were overviewed. Also, were obtained existing opinions on technology adoption in healthcare, such as Electronic Health Records (EHRs), Hospital Information Systems (HISs), and existing difficulties in implementing these. Lastly, current trends, challenges, and advancements in dental practice management software were overviewed.

Methodology.

This chapter describes the primary methods used to achieve the goal and provide a comprehensive theoretical and empirical analysis. These include comparative analysis, statistical and graphical methods, benchmarking, SWOT analysis, AS-IS - TO-BE method, interviewing, and conducting a questionnaire. Also, this part of the research outlines the variables by which the programs are being comparatively analyzed in the following section of the paper.

Research results.

The chapter includes the main findings of the study and improvement suggestions for existing software solutions based on the following:

- The statistical data obtained by conducting a questionnaire on a sample of 33 people and two profound interviews with the dental clinic owner and business manager;
- A functionality, performance, and cost analysis of six dental practice management software using previously defined variables;

- A comparative table created to provide a visual overview and side-by-side comparison of the selected software.

Conclusions, limitations, and future areas for research.

This part of the study describes the conclusions and methodological limitations of the research paper. It also specifies the areas where further study of the topic is possible.

Bibliography.

The chapter provides a list of the references that were reviewed throughout the study.

1.2. Relevance of the topic

The relevance of the topic "Analysis and evaluation of existing software for management of dental practice" is due to a combination of factors that concern not only the medical field but also the general trend towards digitization and automation of all spheres of life in modern society.

Dental practice, as a component of the modern medical field, faces several challenges and problems that require a systematic approach to their solution. One of the problems is ineffective management and organization of work processes in dental practices. Given the rapid development of information technology and its potential to transform the medical field, implementing effective dental practice management software can improve the workflows of dental institutions. However, the following problems complicate medical professionals' work and can negatively impact the quality of dental services and patient interaction (Dhanore et al., 2016).

Dental clinics and offices, despite their size and volume of activity, face the complexity of organizing and coordinating various work processes. From scheduling patient appointments and medical procedures to accounting for medications and maintaining medical records, all these aspects require attention, adherence to standards, and accuracy (Health Informatics, 2019). The problem is that traditional management methods no longer meet the requirements of modern times, and it is necessary to implement more efficient and flexible solutions.

Traditional methods of paper documentation, manual accounting, and insufficient use of information technologies might lead to a waste of time and resources through manual administration of medical records, admitting patients, and other operational procedures requiring significant time and effort from healthcare professionals that could be used to provide quality healthcare.

The growing number of patients, medical records, tests, and diagnostic data leads to a large amount of information that needs to be processed, stored, and might be analyzed. Manual recording and processing of medical data increase the risk of errors in documents, prescriptions, and the planning of procedures, which can lead to negative consequences for patients and reduce trust in the medical institution. Another consequence of the missing effective management system may be inconvenience for patients, such as long wait times, paper documentation, and lack of an effective way to communicate, which can reduce patient satisfaction and lead to lost customers. High-quality patient care is a vital aspect of any medical practice. Effective software can provide quick and convenient access to information, improve the planning and coordination of procedures, ensure efficient medication records, and provide patients with timely and quality treatment.

While operating with outdated and inefficient systems, dental professionals may run into difficulty in conducting analysis and planning. The lack of a centralized and convenient tool for analyzing work processes, planning workloads, and selective analysis of indicators may lead to the complexity of strategic decision-making. The shortcomings of an analytics and reporting system limit the ability to study the demand for services, treatment effectiveness, resource planning, etc.

One of the essential aspects of dental practice and healthcare in general is the security and privacy of personal data, which might be negatively affected by using manual and outdated management methods. The increase in the number of electronic medical records requires attention to the protection of patients' personal information from unauthorized access. Ensuring the privacy and security of medical data is crucial, especially in the context of the growing number of cyber threats and data breaches. Traditional data accounting may be less secure against unauthorized access, and a breach of confidentiality of personal data may lead to information leakage and legal violations (Regulation EU 2016/679). It is necessary to point out that legislation regarding the storage and processing of personal data is becoming increasingly strict and regulated.

Requirements for confidentiality, data protection, and information processing standards require the availability of specialized software for appropriate work with medical information (Health Informatics, 2010).

As digital technologies have become an inseparable part of all industrial operation areas, medicine is no exception. Providing digital infrastructure for dental practices will help them be more competitive and technologically advanced and provide the right level of service.

Therefore, identifying and solving the problem of inefficient management of dental practice through the analysis and improvement of existing software is an extremely urgent task that can significantly improve the quality of medical services, make them more accessible and convenient for patients, increase the efficiency of medical professionals and meet modern safety standards and data privacy.

Improving dental practice management software is key to boosting operational efficiency, raising the quality of healthcare delivery, and ensuring compliance with modern data security and privacy standards. Considering these aspects, further analysis and revision of practice management software functionalities of dental practice management software becomes an urgent task to enhance operations and ensure a high level of service.

1.3. Objectives of the project

The objectives of the project are designed to address critical aspects of improving the management of dental practices through software solutions. These objectives serve as the guiding principles for the research and development efforts and outline the desired outcomes of the paper:

1. Comprehensive literature review:
    - Conducting an extensive review of existing literature on dental practice management software, electronic health records, and technology adoption in healthcare.

- Identifying the current trends, challenges, and advancements in dental software applications.

2. Assessment of current software solutions:
    - Evaluation of the functionality, features, and usability of available dental practice management software systems.
    - Analysis of the strengths and weaknesses of these software solutions in meeting the diverse needs of dental practices.
3. Identification of gaps and limitations:
    - Identifying gaps, shortcomings, and limitations in the existing software that hinder efficient dental practice management.
4. User experience and workflow analysis:
    - Assessing the user experience of dental practitioners, administrative staff, and patients when interacting with the software.
    - Analysis of the impact of software on workflow processes, appointment scheduling, patient records management, and communication.
5. Data security and privacy evaluation:
    - Examination of the security measures and data privacy protocols implemented by different software solutions.
6. Integration and interoperability study:
    - Investigation of the compatibility and interoperability of dental practice management software with other healthcare systems and technologies.
    - Exploring possibilities for seamless integration with electronic health records and diagnostic tools.
7. User training and support considerations:
    - Exploration of the training and support mechanisms provided by software vendors to assist dental professionals in effectively utilizing the software.
8. Recommendations and guidelines:
    - Development of evidence-based recommendations and guidelines for dental practices seeking to implement or upgrade their practice management software.
9. Contribution to knowledge and practice:
    - Contribution of valuable insights and findings to the field of dental informatics, enhancing the understanding of software solutions' impact on dental practice management.

The overarching goal of these objectives is to create a holistic understanding of the current landscape of dental practice management software, identify areas for improvement, and provide practical recommendations for optimizing software solutions to meet the evolving needs of dental practices.

2. LITERATURE REVIEW

2.1. Introduction

In recent years, The World Health Organization has been focusing more on promoting the significance and necessity of health care, including taking care of oral health. Throughout various kinds of research, it has been identified that oral health directly impacts general health (Shamsoddin et al., 2021).

According to the Statista website (Statista, 2021), current indicators show an upward tendency of value growth in the dental industry, and the Dental Services market is forecasted to continue to grow. On the other hand, a more recent study of the dental market raises the fact that with the spread of COVID-19, the number of customers has decreased (The Express Wire, 2023) and therefore brought other challenges for the dental clinics to focus on to continue to provide their services to the patients.

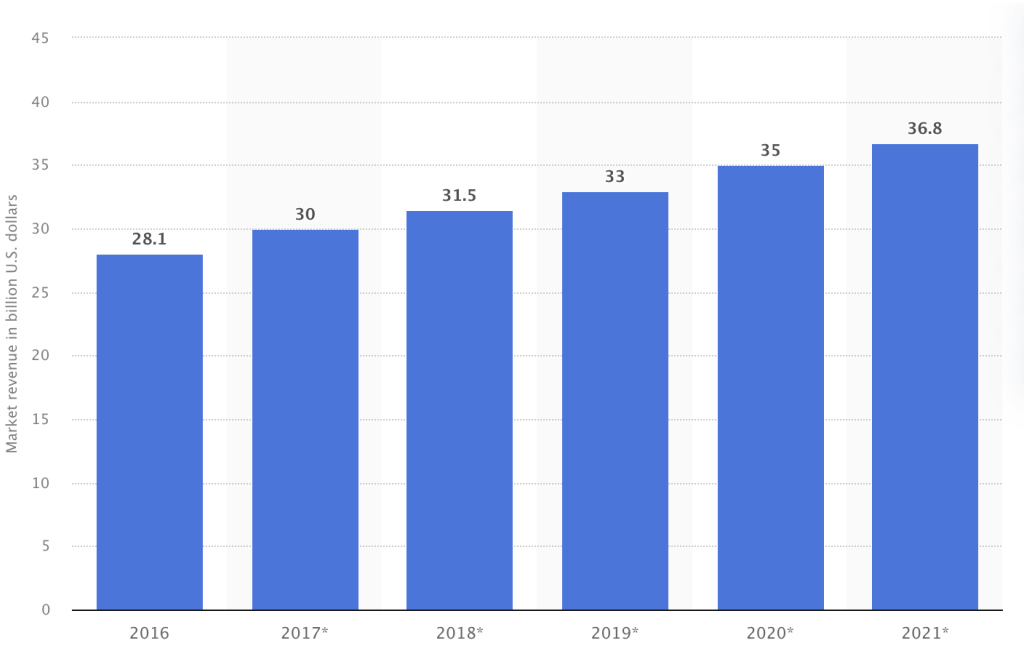

Figure 1. Estimated global dental market from 2016 to 2021 (Statista, 2021)

At the current market situation, as well as external factors challenging the clinics' work, several issues need to be addressed and presented with the solution. For instance, some clinics started implementing online/remote consultations to ensure that patients who needed treatment could

be provided with one. Nowadays, dental practices and clinics must manage a large volume of patient and business data daily. Applying this software is beneficial to overall operations and is used to simplify its management and improve and update the services clinics provide. Its usage also helps them to computerize the processes with a specifically built system. Most dental clinics already use various management applications (software) to perform their operations: daily administrative tasks, services rendered, and patient experience management.

2.1.1. Defining management systems and software

Inappropriate business process management and the absence of a comprehensive systematic approach result in useless processes, raised levels of inefficiency, and reduced competitiveness in the market, which eventually directly affects the enterprise's potential for success. Among the most meaningful changes in a company's life cycle are the automation of business processes and switching from a function-based organizational structure to a process-oriented one *(Kasim et al., 2018)*.

Today, the successful development of an enterprise and its existence directly depends on the effective functioning of the management system, which necessitates the improvement of both itself and the methods for assessing the management system's effectiveness in an enterprise. Of particular relevance is managers' ability to correctly evaluate the management system's effectiveness in real-time, taking into account its impact on the performance of the enterprise and making high-quality management decisions in a rapidly changing, unstable environment. Besides, years of studies have shown that integrating IT solutions significantly and positively affects performance and economic growth in general, not only being a tool for automating existing processes but also bringing changes that may lead to further productivity enhancements (Dedrick et al., 2003).

An important aspect to consider is process performance speed. Research proves that a user's satisfaction with a website, software, or another system directly correlates with the time spent on conducting an operation. The study shows that a user will leave a website after 3 seconds of waiting, and only 30% of users are patient enough to wait 6-10 seconds (Gardner, 2011).

Thus, business process optimization is an essential stage in the life cycle of an enterprise, which mainly involves the implementation of specific information systems or the integration of existing information systems. Researchers describe the marriage of business process management techniques with informational systems as an effective solution. An enterprise may only be as efficient and flexible as its business processes interact (Rubens & Olavsrud, 2022).

An information system is a set of interconnected elements that work together to achieve a specific goal. An information system (IS) is defined as a set of interconnected components that function collectively to perform input, processing, output, storage, and control operations to produce information as a result of data transformation that can be used to support forecasting, planning, control, coordination, decision-making, and operational activities in an institution or facility (Basholli et al., 2023).

An enterprise information system (EIS) provides a technology platform that enables organizations to integrate and coordinate their business processes. An EIS provides a single system that is central to the organization and ensures that information can be shared across all functional levels and management hierarchies. Enterprise systems create a standardized data structure and are very useful in eliminating the problem of information fragmentation caused by the multiplicity of information systems in an organization. There are several types of Enterprise Information Systems, namely Enterprise Resource Planning (ERP), Enterprise Risk Management (ERM), Customer Relationship Management (CRM), and Supply Chain Management (SCM) (Fig. 3.).

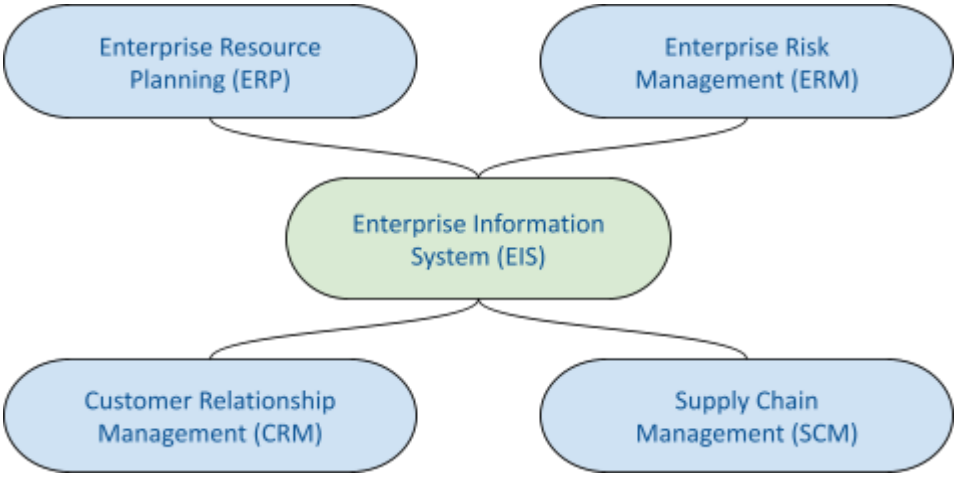

Figure 2. Main types of software and systems in an enterprise (made by the author)

ERP (Enterprise Resource Planning) is a management tool that balances the supply and demand of the company as a whole, has the ability to connect customers and suppliers in a unified chain of availability, adopts proven business processes for decision-making, and integrates all decision-making, functional parts of the company such as sales, marketing, manufacturing, operations, logistics, purchasing, finance, new product development, and human resources. So that businesses can run with high levels of customer service and productivity, lower costs and inventory, and provide the basis for e-commerce (Wahdiniawati et al., 2023).

ERM (Enterprise Risk Management) is about estimation, calculation, finance, and risk management *(Grace et al., 2014)* that is mutually integrated, comprehensive, and strategic by focusing on corporate strategy, including objectives and decision-making processes, work organization, resource allocation, value enhancement, organizational culture, and optimizing operations efficiently which is primarily focused on the achievement of company goals (Agustina & Baroroh, 2016).

CRM (Customer Relationship Management) is viewed as a set of practices developed to put a company in more profound and closer contact with its customers, to understand them better, and to provide more valuable services to them, with the overarching goal of increasing the value of each customer to the company. It is a broader company perspective on analyzing and influencing customer behavior through analysis and insightful communications to enhance customer engagement, retention, and profitability (Zulyanti & Irawan, 2023).

SCM (Supply Chain Management) is a method for managing the flow of products, information, and funds in an integrated manner that involves various parties from upstream to downstream consisting of suppliers, companies, distribution, and logistics services (Wahdiniawati et al., 2023).

Hardware and software are mainly described as components of an information system. Software elements are applications, operating systems, and multiple programming utilities. Hardware is the physical technology that contains and runs the software, stores, converts, transports data, and provides the means to input and output information from the system (Basholli et al., 2023).

The software allows companies to manage their resources internally and their client base for maximum impact. Today, it is impossible to imagine a company that does not have software to manage its business processes. The very introduction of e-governance is one of the main criteria for the success of companies in the market. The software, combined with management technologies, will enable the company to exercise business processes and facilitate the work of both employees and management. The development of technology became the beginning of a new management level based on the efficient use of resources at minimal human costs.

2.1.2. Information management systems and software in healthcare

Paper records management systems are still quite common in hospitals, especially in developing countries. However, they are said and proven to have significant flaws affecting treatment efficiency and quality, personnel productivity, general performance, and last but not least – the hospital's storing abilities. Nowadays, the majority of governments' health systems have switched to electronic management systems (EMC). Many are still on the way to digitizing their healthcare due to rapid changes in the global environment, such as the digital revolution, the emergence and spread of the Internet worldwide, increased population and healthcare needs, and the COVID-19 pandemic.

The rise in data collection has led to the development of new solutions to keep up with demands – the so-called Hospital Information System, which is available in the software market, was designed and programmed to assist in managing administrative, financial, clinical data and also handle the workflow on daily medical services.

HIS is an integrated information system that reduces uncertainty due to decentralized data storage, improves patient treatment flow by increasing the users' knowledge, and allows rational decisions to be made from the information provided (International Journal on Information, 2016). Also, HIS may be defined as a system that aims to provide where and when needed with the necessary information collected through electronic devices about healthcare services and management (Demirel, 2018).

The hospital information system (HIS) has followed its development line since the 1960s, when these systems were shared worldwide. Respectively, the concern for people's well-being and the need for preventive health services were also considered very important. This development cycle came to an end in the 1970s. Then, the first HIS was implemented in El Camino Hospital in California in 1972. The abilities of computers and systems at that time were limited. Thus, the hospital information management system could only provide request inputs and reporting services, not emergency and outpatient services. Respectively, the second generation of HIS development appeared in the mid-1970s and ended in the late 1970s with a financial implementation functionality.

In this process came the introduction of database technologies in the early 1980s – computers have changed from single- to multi-tasking, user-friendly computers. In the 1980s began the fourth generation of information systems development that came with new technologies focused mainly on laboratory and pharmacy issues, patient care planning, and data storage. A crucial innovation of this era is the upcoming integration of third-party systems, for example, accounting systems. Taking HIS as a base, private clinics also adopted information management software that fit their needs.

With the significant rise of investments in HIS development in the 1990s, many health institutions were prompted to adopt the use of HIS. Also, the spread of these systems was affected by the decrease in computer prices and the rise of computers' processing power. In 1991, the Institute of Medicine shared the report "Computer-Based Patient Records: Essential Technologies in Health Care" (Demirel, 2018). This report outlines the concerns of paper-based records and encourages using electronic patient records systems. Also, the report pointed out that doctors play crucial roles in the system and defined the need to make the system centered around patients' well-being and comfort. After the 2000s, this and the unprecedented increase in healthcare quality became the priority of HIS development approaches. The currently improved tools of the technology world, such as worldwide internet access, portable devices, and wireless technologies, have been used to make HIS more relevant in the healthcare sector than ever before. Nowadays, electronic management systems (EMS) and practice management (PM) systems are available to the whole healthcare industry to be implemented in respective hospitals and clinics.

Hospital management information systems are diverse and aim to include all resources, tools, and functions necessary for doctors, clinic owners, and staff. The functionality of hospital information and management systems is similar to currently existing practice management (PM) softwares.

Therefore, the functions of HIS are (Demirel, 2018):

- Financial management aspect:
    - Effortlessly managed daily accounting transactions via computer;
    - Constantly keeping and recording the files of hospital staff;
    - Providing the necessary numerical data and management information for evaluation and control of transactions, minimizing the expenses in the investment decisions;
    - Cost-effectively establishing functional financial sub-systems;
    - Using a financial transaction and material distribution system for easy record storing and management.
- Personnel management aspect:
    - Getting up-to-date data and correction of information processes from files when needed;
    - Ensuring control over the implementation of tasks;
    - Drawing out the study analysis reports of each hospital's center to analyze personnel performance and make administrative decisions;
    - To provide relevant information on cost distribution about labor costs, quality control, and personnel productivity to make management decisions;
    - Providing enhanced information support on the effects of diseases, drugs, diagnostics, and treatments in real-time;
    - Getting to know the unique talents and document situations for staff development and promotion;
    - Getting data about patients' ongoing treatment quality, performance, and cost for making decisions;
    - Using Patient Management Information Systems in the proper context and standard.

The purposes of use of hospital management information systems are defined to be (Demirel, D. et al., 2018):

- Collecting basic information about the patient into CV instantly through an electronic device to be easily accessed on demand;
- A modern practice management information system is established to prevent the loss of time;
- The diagnostic disease process is fast, reliable, and based on up-to-date information recorded previously on the patient's CV;
- Hospital information management systems aim to be "user friendly" and easily accessible for all the users – doctors, hospitals or clinic staff and owners;
- Necessary data is provided through fast-track searching archiving systems before the diagnosis of the disease to ensure qualified and on-time service delivery;
- Increase in incomes through billing and official document preparation processes are performed without any financial complication;
- All trading and material distribution operations in hospitals are carried out through computers;
- Receiving information and making specific changes is quickly done by the system administrator when necessary;
- Medical research and high-quality communication are provided by exchanging information between one hospital's staff and different hospitals in general;
- Protective and curative health services can be managed;
- Establish an effective financial transaction sub-system.

Also, the main benefits of hospital information management systems were summarized (Demirel, 2018):

- Reducing the red tape by arranging all forms used in the hospital through the system.
- Statistical results can be obtained according to different criteria;
- Unnecessary usage and leakage are prevented by input, output, control, and follow-up of all kinds of materials in the hospital;
- During operation, the relevant images are saved, and the reporting system is recorded in the digital environment;

- All information is constantly kept in an electronic environment by staff using the digital archiving system;
- The personnel's performances are constantly followed and are managed to meet the highest standards of the hospital;
- The acceleration of the health services presentation ensures continuity of patient treatment and patient satisfaction;
- Support is provided for personnel management, logistics operations, and case costs. Better strategic decisions are made by increasing the efficiency of the healthcare organization's supply chain.

Information management systems and software have become integral components of modern healthcare systems, revolutionizing how medical data is collected, stored, processed, and utilized. In an era characterized by rapid technological advancements and an increasing reliance on data-driven decision-making, integrating information technology into healthcare practices has become a crucial strategy to enhance patient care, streamline administrative processes, and improve overall efficiency.

Another key technology that is being increasingly embraced (Fig. 1.) is Electronic Health Records (EHRs).

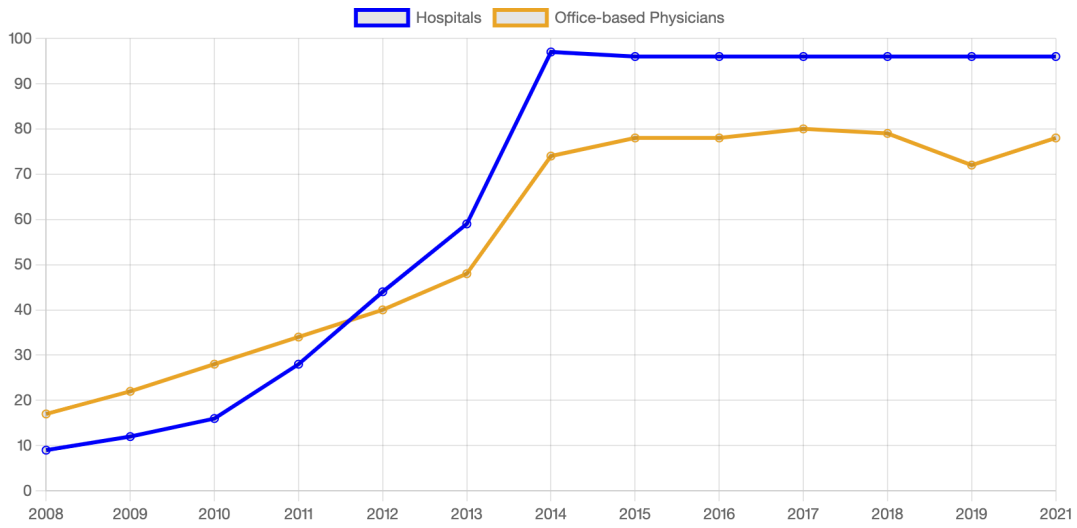

Figure 3. National Trends in Hospital and Physician Adoption of Electronic Health Records (HealthIT.gov, 2021)

In 2006, the Health Information Management Systems Society (HIMSS) presented the following definition of the EHRs system:

The Electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. This information includes patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports. The EHR automates and streamlines the clinician's workflow. The EHR can generate a complete record of a clinical patient encounter and support other care-related activities directly or indirectly via the interface, including evidence-based decision support, quality management, and outcome reporting.

According to Seymour et al. (2012), EHRs are meant to revolutionize the industry and address most practitioners' needs. The healthcare system benefits in several ways due to the adoption of this innovation:

- The easy and fast documentation process of patient data such as treatment history, prescriptions, laboratory orders and results, digital image scans, and medical notes;
- Creating advanced patient cards including all the needed data: name, age, sex, address, contact, and insurance information, etc.;
- Making patient records remote and portable;
- Ensuring compliance with laws and regulations, as well as insurance companies;
- Control of accurate billing, accounting, and claims;
- Providing confidentiality and compliance with the Health Insurance Portability and Accountability Act (HIPAA);
- Application of Computerized Physician Order Entry (CPOE), Laboratory Information System (LIS), Radiology Information System (RIS), and Picture Archiving Communications System (PACS);
- Integration of pharmacy systems for medication administration and reducing drug errors.

Thus, information management systems and software in healthcare continue to play a crucial role in transforming healthcare delivery and administration. The significance and benefits of these systems can be categorized and summarized into several key aspects such as:

1. Efficient data management. Information systems allow healthcare organizations to capture, organize, and store vast patient data, including medical histories, diagnostic results, treatment plans, and medication records. This centralized and digitalized approach improves data accuracy and accessibility and reduces the risk of errors associated with manual record-keeping.
2. The enhanced patient care. Integrating electronic health records (EHRs) and clinical decision support systems (CDSS) empowers healthcare professionals to make informed and evidence-based clinical decisions. Real-time access to patient information, medical guidelines, and best practices improves diagnostic accuracy, treatment selection, and patient outcomes.
3. Workflow optimization. Information systems streamline clinical workflows by automating administrative tasks, appointment scheduling, and billing processes. This enhances operational efficiency, reduces administrative burden, and allows healthcare providers to focus more on patient care.
4. Data analytics. Healthcare software solutions enable data analysis and reporting, providing valuable insights into patient populations, disease patterns, treatment outcomes, and resource utilization. These analytics support evidence-based practices, epidemiological research, and strategic planning.
5. Remote patient monitoring. With the rise of telehealth (technologies to remotely access healthcare services) and mobile health applications, information systems facilitate remote patient monitoring, allowing healthcare providers to monitor vital signs, chronic conditions, and recovery progress outside traditional healthcare settings.
6. Interoperability and communication. Health information exchange (HIE) platforms enable seamless data sharing and communication between different healthcare facilities, ensuring continuity of care and reducing redundant tests and procedures.
7. Cost savings. While initial investments in information management systems and software may be substantial, they often lead to long-term cost savings by reducing paperwork, minimizing duplicate tests, optimizing resource utilization, and preventing medical errors.

As technology evolves, several trends are shaping the future of healthcare information management systems and software. Further introduction of innovative technologies is expected in this field, as well as their advancement and more precise adaptation to the specific needs of

healthcare institutions and facilities. For example, the following progressive features are used in present-day clinics and hospitals:

1. Artificial Intelligence (AI) and machine learning. AI-powered applications, such as predictive analytics, image recognition, and natural language processing, are revolutionizing diagnostics, personalized medicine, and clinical decision support.
2. Blockchain technology. Blockchain can potentially enhance data security, interoperability, and patient consent management, thereby improving data sharing and patient engagement.
3. Telehealth and remote monitoring. The COVID-19 pandemic has accelerated the adoption of telehealth platforms and remote monitoring solutions, enabling virtual consultations, remote patient monitoring, and enhancing access to care.
4. Data analytics and population health management. Advanced data analytics tools enable healthcare organizations to analyze large datasets, identify population health trends, and develop targeted interventions to improve public health.
5. Patient engagement and self-care. Patient portals, mobile apps, and wearable devices promote patient engagement, self-care, and proactive management of chronic conditions.

In conclusion, information management systems and software are indispensable components of modern healthcare systems. They offer many benefits, from improved patient care and streamlined workflows to data-driven decision-making and cost savings. The successful integration and utilization of information management systems and software have the potential to revolutionize healthcare delivery, enhance patient outcomes, and pave the way for a more efficient and patient-centric healthcare ecosystem.

2.1.3. Information management systems and software in dental practice

As indicated in the previous part of the literature review, in today's rapidly evolving healthcare landscape, integrating information management systems and software has become pivotal in optimizing patient care, enhancing practice efficiency, and elevating overall healthcare quality. This holds not only for general healthcare settings but also for specialized fields like dentistry. Information management systems and software tailored to dental practices have revolutionized

how oral health professionals manage patient data, streamline administrative tasks, and make informed clinical decisions, reducing manual data management and paperwork. This comprehensive exploration delves into the multifaceted realm of information management systems and software in dental practice, highlighting their significance, benefits, challenges, and prospects.

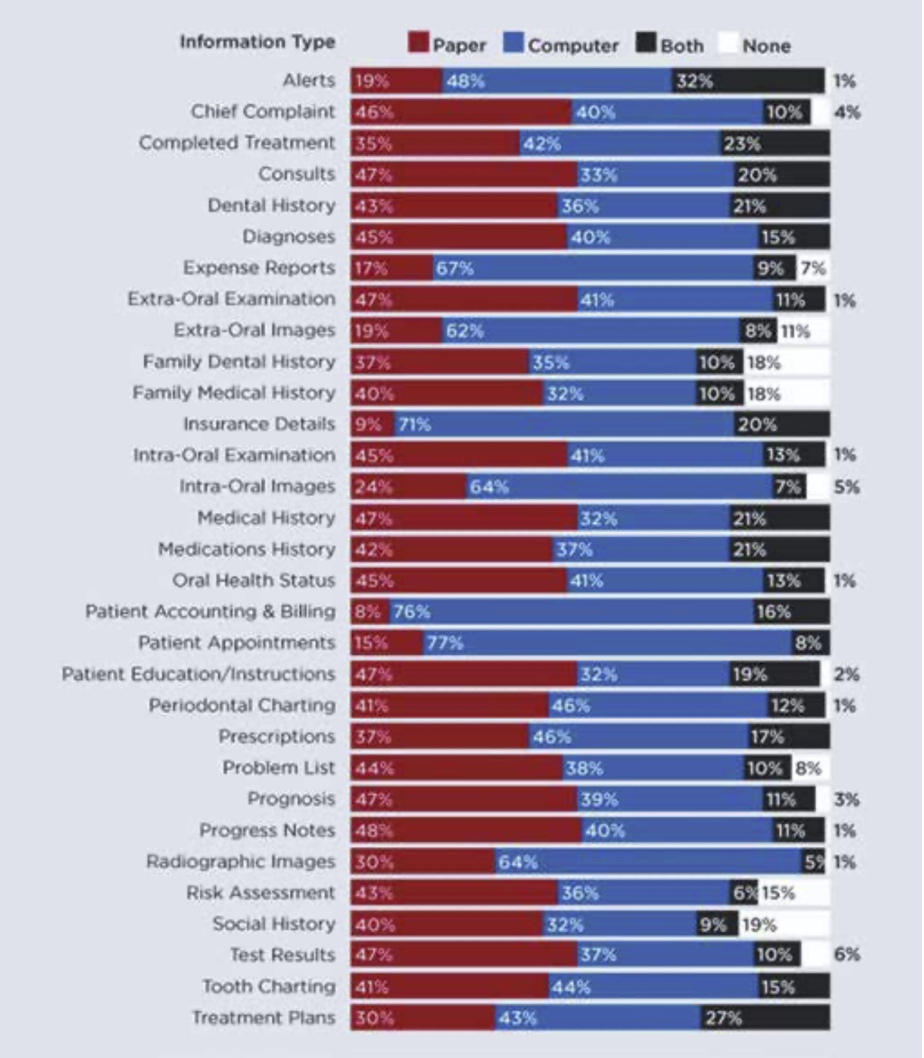

Figure 4. Information storage methods of major clinical and administrative information in dental practices (Acharya et al., 2017)

Incorporating information management systems and software into dental practice brings forth an array of transformative benefits that extend beyond traditional pen-and-paper methods. The significance and advantages of these systems can be grouped into several key categories (Vandenberghe et al., 2010; Cederberg et al., 2014; Acharya et al., 2017):

1. Efficient patient record management. Dental practices generate extensive patient records, including medical histories, treatment plans, radiographs, scans, and notes. Information management systems digitize and centralize these records, facilitating seamless storage, retrieval, and updates. This results in reduced paperwork, minimized errors, and enhanced accessibility for practitioners.
2. Streamlined clinical workflows. Dental software solutions optimize clinical workflows by automating appointment scheduling, reminders, and treatment planning. This streamlined approach fosters efficient patient flow, decreases waiting times, and ensures timely care delivery.
3. Clinical decision support. Software applications offer clinical decision support tools, aiding dentists in treatment planning and diagnosis. Access to evidence-based guidelines, drug interactions, and treatment alternatives enhances diagnostic accuracy.
4. Treatment coordination and communication. Dental teams collaborate effectively through software platforms, facilitating secure communication and enabling real-time sharing of patient information. This enhances interdisciplinary care and patient outcomes.
5. Billing and administrative efficiency. Information management systems simplify billing, insurance claims, and financial management. Integration with electronic health records (EHRs) ensures accurate coding, reduces billing errors, and accelerates reimbursement processes.
6. Data analytics and performance metrics. Dental software enables data-driven insights into practice performance, patient demographics, treatment outcomes, and resource utilization. Analyzing these metrics informs practice growth strategies and quality improvement initiatives.
7. Integrated imaging systems. Imaging systems such as digital X-rays, cone-beam computed tomography (CBCT), and intraoral cameras provide detailed and high-resolution images of oral structures. Digital imaging systems streamline the documentation process by eliminating the need for film processing. Images can be captured, stored, and accessed electronically, leading to a paperless and more efficient workflow. This also reduces the risk of lost or damaged records.

8. Patient engagement and education. Dental software often includes patient portals and education modules that empower patients to participate in oral health management actively. Access to treatment plans, educational materials, and appointment reminders fosters patient engagement.
9. Continuity of care. Information systems facilitate seamless sharing of patient information within dental practices, as well as with specialists and healthcare institutions. This enhances continuity of care, reduces duplicated diagnostic procedures, and ensures comprehensive treatment planning.

Also, Estai et al. (2016) mention the following benefits of implementing teledentistry and other innovations depicted in Table 1.

Level	Benefits
Patient	• Provides access to primary and specialised dental care • Allows reception of a timely diagnosis and follow-up appointment • Improves communication between the care team and patients • Facilitates patient education • Avoids costs and risks associated with travelling and overnight accommodation
Care provider	• Increases dental workforce capacity • Allows effective triaging of patients • Reduces waiting lists • Reduces inappropriate referrals • Improves communication amongst care providers • Connects local dental practitioners with dental consultant at hub site • Reduces isolation of health professionals practising in isolated regions
Quality of care	• Increases efficiency of care delivery • Improves clinical outcomes • Reduces pain and co-morbidities associated with delayed diagnosis and treatment • Facilitates monitoring patient's condition
Societal	• Minimises burdens of parents or caregivers missing work • Reduces frequency of missed school days • Reduces inequity and inequalities in oral health in the community • Addresses specific needs of underserved populations

Table 1. Benefits of teledentistry (Estai et al., 2016)

Although the advantages of information management systems and software in dental practice are compelling, their successful integration might be accompanied by particular challenges and considerations (Jayatissa, 2023; Naamati-Schneider & Salvatore, 2022; Cederberg et al., 2014; Acharya et al., 2017):

- For example, personal data security and privacy. Protecting sensitive patient information from data breaches and ensuring compliance with privacy regulations (such as the Health Insurance Portability and Accountability Act, or HIPAA) is paramount. Robust security measures and encryption protocols are essential.
- Another vital aspect is vendor selection. Choosing a suitable software vendor and platform requires careful consideration of the practice's unique needs and workflows. Also, customization to align with practice requirements may be necessary.
- According to reviewed literature sources, programs are created for users but are only sometimes accompanied by documentation on how to use the software. Thus, transitioning to their first or new software system demands training for dental professionals and support staff. Ensuring user comfort and proficiency is crucial to maximize system benefits. Also, adequate technical support, software updates, and maintenance are vital for sustaining optimal system performance and addressing issues promptly.
- Also, the non-perfected integrations of other programs are currently observed. Integrating dental software with other healthcare systems, including EHRs and diagnostic tools, can present interoperability challenges, though seamless data exchange is essential for comprehensive patient care.

Aside from the difficulties that arise from the specifics of the software functionality, such as data protection capabilities, the presence of supporting documentation, and the ability to integrate third-party programs, there are barriers to the adoption of such management systems on several levels (Estai et al., 2016):

Level	Barriers
Individual	• Lack of research on patient's acceptance of teledentistry services • Poor levels of IT literacy • Resistance to new technologies • Lack of direct patient contact • Concerns about data security and inappropriate access of health records • Concerns with decline in the accuracy and quality of health information • Increased clinical workload and consultation time • Increased costs and practice expense
Infrastructural	• Lack of internet access and poor connectivity availability in rural and remote regions • Hardware and software incompatibility • Complexity of the technology • Funding sustainability • Unavailability of technical expertise • Lack of training in the use of technology associated with telemedicine • Lack of ongoing technical support

Organisational	• Incompatibility of telemedicine with current healthcare system • Lack of reimbursement structure • Lack of copyright, licensure and taxation guidelines • Malpractice and medico-legal issues • Bureaucratic difficulties • Difficulty in coordination between remote and hub sites

Table 2. Barriers to the uptake of dentistry (Estai et al.,2016)

The landscape of information management systems and software in dental practice is poised for further evolution, driven by emerging trends, technological advancements, and the entire healthcare sector. Here are some innovative features that are expected to expand and evolve (Jayatissa, 2023; Naamati-Schneider & Salvatore, 2022; Schwendicke et al., 2020):

- The expansion of tele-dentistry platforms enables remote consultations, virtual screenings, and tele-diagnosis, enhancing access to care, especially in underserved areas.
- AI-powered imaging analysis assists in radiographic interpretation, caries detection, and treatment planning, aiding clinicians in making precise diagnoses and treatment decisions.
- Dental practice software may integrate with patient-centric apps and wearable devices for oral health monitoring, encouraging preventive behaviors and real-time data collection.
- Blockchain's potential for secure and transparent data sharing can enhance patient data privacy and consent management, fostering patient trust.
- Advanced data analytics tools enable dental practices to identify oral health trends, target preventive interventions, and contribute to public health initiatives.
- Software applications may leverage patient data to generate personalized treatment plans, optimizing treatment outcomes and patient satisfaction.
- Integrated patient communication tools enable appointment scheduling, reminders, and follow-up communication through preferred channels, enhancing patient engagement.

2.2. Summary

Information management systems and software have fundamentally reshaped healthcare in general and, specifically, dental practice, empowering oral health professionals to provide higher-quality care, improve practice efficiency, and enhance patient experiences. The benefits of

streamlined workflows, enhanced clinical decision support, and improved patient engagement demonstrate the pivotal role of these systems in modern dental care. While challenges such as data security and interoperability persist, ongoing advancements in teledentistry, AI, and patient-centric technologies herald a future where dental practice software continues to drive innovation and redefine oral healthcare delivery. As the dental industry embraces the digital age, the effective integration and utilization of information management systems and software will remain essential to fostering a patient-centric dental ecosystem.

In today's world, information systems and software are critical to effectively managing a dental practice. These technologies allow for the optimization of data processing and improvement of work processes and directly impact the quality of medical care, increasing patient satisfaction and contributing to the practice's growth.

Analysis and evaluation of existing dental practice management software requires a comprehensive approach. The literature review confirms the relevance and reveals the critical aspects of this topic. When considering the advantages, it is essential to consider the practicality of these solutions in the daily work of dental clinics. Ensuring data security and privacy and integration with existing healthcare systems are vital aspects that require detailed study and management. Gaps that may be revealed during the analysis should be considered as opportunities for further improvement.

Based on an in-depth analysis of literary sources, determination of the dental practice's needs, and implementation of innovative approaches, information systems, and software are an integral part of the successful functioning of modern dental clinics. Their role in managing patient information, improving data processing, optimizing workflows, and improving patient satisfaction is essential to providing high-quality and efficient dental care. However, successful implementation requires proper personnel training and continuous systems improvement based on the latest technologies and best practices. Understanding the importance of information systems and software for dental practice has a profound impact not only on the quality of medical care but also on patient relationships and the clinic's overall success. Lack of suitable information tools can lead to patient dissatisfaction due to inadequate management and processing of their information. However, it is essential to note that implementing information systems and software into a dental practice

requires careful planning, resources, and time. The transition from traditional methods to digital data processing can be challenging for clinic staff, especially those without adequate training or experience with technology.

Another critical aspect is interaction with patients. Implementing patient portals and applications can contribute to the involvement of patients in their dental treatment and care. Strengthening communication, tracking one's condition, and having access to educational materials can contribute to higher levels of self-care and improved health. In addition, information systems and software can become key tools for research and data analysis, opening opportunities for developing new treatments, identifying trends in morbidity, and contributing to continuous improvement of practice.

In conclusion, information systems and software in dental practice have a powerful potential to optimize processes, improve patient interaction, raise treatment quality, and develop a scientific research base.

3. METHODOLOGY

When writing a master's thesis and highlighting its issues, theoretical and empirical research methods are used. The theoretical method includes studying functional and structural aspects of dental management software, and the empirical method in analyzing specific software used by dental clinics and identifying its shortcomings. The characterization of the literature makes up one-third of the study, and the rest is the analysis of software in dental clinics in the next chapter, which became the basis of the empirical analysis.

The first stage of the study includes:

- Choice of scientific problem and research topic;
- Definition of the object and subject of research, goals, and main tasks.

The second stage of the research contains:

- Choice of methods and development of research methodology;
- Directly unique processes of scientific research itself.

The third (final) stage involves substantiating and formulating conclusions and practical recommendations. Graphically, the study can be depicted in Table 3.

Theoretical analysis	• Study of the concept of information systems and software; • Investigating the meaning of information systems and software in the healthcare industry; • Describing the concept and use of dental clinic management software;
Empirical analysis	• Conducting a survey: 1) A list of questions relevant to the study was created; 2) The questionnaire was formed and sent to dentists, clinic owners, and staff; 3) The results were analyzed. • Conducting interviews with the owner of Smile House dental clinic and business manager of Coradent clinic Diego, located in Valencia: 1) analysis of previously sent and filled out questionnaire; 2) interviewing the owner with additional questions; 3) analyzing the results and making conclusions. • Selection of software for further research based on the conducted questionnaire and interviews; • Analysis of the selected dental practice management software; • Identifying problematic aspects of existing solutions and proposing ways for improvement.

Table 3. Methodology of scientific research (made by the author)

Thus, the theoretical stage of the study is associated with a detailed analysis of the literature, the theoretical foundations of the concept of software, the definition of information systems in general, and information systems used in healthcare and dental clinics in particular. The features of the software used in dental clinics were also investigated.

The empirical phase of the research paper involved the development of a questionnaire that was sent to obtain information from stakeholders and interviews conducted with the owner of the Smile House clinic and the business manager of Coradent clinic Diego, located in Valencia. Also, an essential part of empirical research is the deep analysis of existing software using selected variables, which will help determine what might be improved.

The combination of theoretical and empirical research allowed to define the areas of dental practice management software that might be improved in the future. The main methods used for the study are described in the following section of the thesis.

3.1. Methodology of comparative analysis

The methodology of comparative analysis of dental practice management software examines various aspects related to the use of such software in dental clinics and the dentists' performance. It aims to identify the advantages and disadvantages of various software solutions available on the market. To conduct a comparative analysis of dental practice management software, it is necessary to determine the criteria by which the programs will be evaluated. For instance, these can be application functionality (e.g., patient registration, medical record-keeping, appointment scheduling), user interface, availability of technical support, price, etc. After defining the criteria, it is necessary to gather information about the various dental practice management programs in the market. This information can be found on software developer websites, user reviews, forums, blogs, etc. Gathering enough information about each program is essential to make an objective comparative analysis.

For research purposes, as detailed and complete as possible, descriptions of the selected programs on defined variables were created. Comparative analysis was carried out by evaluating available

information about different software solutions, communicating with manufacturing companies and consultant representatives, and testing demo versions of software. Also, the primary sources of information for descriptive analysis of the programs were user reviews on the Internet (the search was targeted at independent evaluators), as well as the respondents' answers, which were obtained after conducting a questionnaire and an interview. Methods used for the comparative analysis are described in more detail below.

Comparison Table

The collected data were synthesized and compiled into a structured comparison table with the help of a graphical method. Each software solution was assigned a separate column, and the rows contained predetermined parameters. The table enabled a parallel comparison of software functionality based on chosen criteria, which form the left-sided columns and rows and represent the following values:

- Operating System Compliance (determines whether the software is compatible with Windows, Linux, or MacOS operating systems);
- Cross-platform options (defines what cross-platform capabilities the software provides - Desktop, Tablet, or Mobile);
- Availability (indicates in which mode it is possible to manipulate the program - Online or Offline);
- Technical Training and Customer Support (describe whether these are provided or not);
- Usability (indicates the availability of the key and additional functions, described below, that are identified based on the previous analysis of the software);
- Access Management (determines whether it is possible to set up custom access types for different users or not);
- Integrations (describes what integrations the software can implement);
- Others.

The "Usability" criterion has been divided into the following categories and subcategories for a more detailed comparison:

- Patient Records
    - Laboratory records keeping;
    - Issuing prescriptions;
    - Patient Portal.

- Billing and Accounting
    - Invoices and receipts;
    - Control of incomes and expenses;
    - Voucher management;
    - Calculating the doctors' commissions;
    - Financial reports;
    - Invoicing insurance companies.
- Appointment Scheduling
    - Booking appointments;
    - Automated reminders;
    - Online appointments.
- Inventory and Pharmacy management
    - Inventory management;
    - Integrated Pharmacy.
- Communication with Patients
    - via SMS;
    - via e-mails;
    - via WhatsApp;
    - Messages customization.

The "Integrations" criterion has also been split into categories for a more precise evaluation:

- Software's products;
- Microsoft Office;
- Imaging systems;
- Electronic Health Records (EHRs).

Also, the "Others" criterion included the following functionalities:

- Transferring the data from previously used programs;
- Data Analytics;
- Voice recognition;
- Gesture recognition.

The right-sided columns are color-coded and represent the six analyzed software selected and described in the previous part of the research paper. These include:

- Gesden G5;
- Aquar Software;
- Cliniwin;
- EasyClinic;
- PracticeDent;
- Periosystem.

Benchmarking method

The dental practice management software benchmarking methodology addresses dental clinics, dentists, and their software needs. Users, such as dental clinics and dentists, can use the benchmarking results to make an informed decision about choosing dental practice management software. The benchmarking method is a valuable approach to analyzing and evaluating existing dental practice management software by identifying gaps and opportunities for improvement. The benchmarking method consists of the following steps:

- Determining the key criteria that are important for evaluating dental practice management software. These criteria include features, functionalities, user experience, customer support, data security, integration capabilities, and overall system performance.
- Researching to identify the most used among the sample dental practice management software solutions.
- Determining the strengths and weaknesses of the current software based on the benchmarking assessment. Identifying the areas where the software excels and where it needs improvement. This analysis clearly explains the software's performance and areas that require attention.

- Based on the identified weaknesses and gaps, identifying opportunities for improvement. Looking for specific areas where the software can be enhanced to meet or exceed the benchmarking criteria. This can involve adding new features, improving existing functionalities, enhancing user experience, or addressing customer support or data security shortcomings.

SWOT analysis method

A SWOT analysis is a common tool used in business and research to assess a particular subject's strengths, weaknesses, opportunities, and threats. In the context of analyzing and evaluating existing dental practice management software, conducting a SWOT analysis can provide valuable insights into the current state of the software and identify areas for improvement. Here is how a SWOT analysis can be applied:

Strengths:	🔹 Identifying the key strengths of the dental practice management software, such as a user-friendly interface, comprehensive features, integration capabilities, and efficient appointment scheduling. 🔹 Evaluating the software's performance in terms of reliability, speed, and data security. 🔹 Assessing the software's ability to streamline administrative tasks, improve workflow, and enhance overall practice efficiency.
Weaknesses:	🔹 Identifying the weaknesses or limitations of the software, such as outdated user interface, lack of customization options, inadequate reporting capabilities, or difficulty in learning and adapting to the software. 🔹 Evaluating any technical issues, bugs, or glitches that may hinder the software's performance. 🔹 Assessing any shortcomings in terms of customer support, training, or documentation provided by the software vendor.
Opportunities:	🔹 Identifying potential areas for improvement or enhancement in the software, such as adding new features or functionalities to meet evolving industry needs. 🔹 Evaluating opportunities for integrating with other dental software or third-party applications to enhance interoperability.

	🔹 Assessing the potential for expanding the software's user base, targeting specific market segments, or exploring new geographic markets.
Threats:	🔹 Identifying potential threats or challenges that the software may face, such as increasing competition in the market, the emergence of new technologies, or changing industry regulations. 🔹 Evaluating any potential risks related to data breaches, cybersecurity, or data privacy concerns. 🔹 Assessing any negative feedback or reviews from current users that may impact the software's reputation and market position.

Figure 4. Main types of software and systems in an enterprise (made by the author)

AS-IS-TO-BE method

The AS-IS-TO-BE method is a structured approach used to analyze and evaluate existing systems or processes and identify gaps and opportunities for improvement. In analyzing and evaluating existing dental practice management software, the AS-IS - TO-BE method can be applied to assess the current state of the software and define the desired future state. The method includes:

AS-IS analysis:

- Gathering information about the existing dental practice management software, including its features, functionalities, and limitations. Identifying how the software is currently used and its impact on the dental practice's operations.
- Assessing the challenges, limitations, and inefficiencies associated with the current software. Identifying pain points, such as difficulty in scheduling appointments, lack of integration with other systems, or inadequate reporting capabilities.
- Collecting feedback from dental practice staff who use the software daily. Understanding their experiences, concerns, and suggestions for improvement. This feedback can provide valuable insights into specific areas that need attention.

TO-BE design:

- Based on the analysis of the current software, defining the desired features, functionalities, and improvements that would address the identified pain points and gaps. Considering industry best practices and emerging trends in dental practice management software.
- Creating a detailed plan outlining the steps and actions required to achieve the desired future state. This may include software enhancements, integration with other systems, user training, or process improvements.
- Identifying the most critical improvements that will have the greatest impact on the dental practice's operations and addressing the identified pain points. Prioritizing these improvements based on their feasibility, cost, and potential benefits.
- Outlining the steps required to transition from the current state to the desired future state. Considering factors such as data migration, system downtime, user training, and stakeholder communication.

Questionnaire method

A questionnaire was developed to survey clinic owners, dentists, and stakeholders related to the use of the software to identify gaps in the software that would improve usability, missing features, etc. Questionnaires were sent to all interested parties who use the software and, accordingly, can provide their vision of improving it or replacing it with another.

To specify what exactly was learned, the questions of the questionnaire are listed:

1) What is your name?
2) What is your role in the dental practice? I'm a…
    a) dentist
    b) dental clinic owner
    c) dental clinic staff
3) Where is your clinic located?
4) Which dental practice management software do you currently use?

5) Please rate the importance of the following features in dental practice management software, on a scale of 1 to 5 (1 being not important, 5 being very important):
    a) Appointment Scheduling
    b) Patient Records Management
    c) Treatment Planning and Charting
    d) Billing and Invoicing
    e) Insurance Claims Management
    f) Inventory Management (for supplies)
    g) Reporting and Analytics
    h) Integration with Imaging and X-Ray Systems
    i) Patient Communication and Reminders
    j) Integration of Accounting System
    k) Integration of Cloud or Back-up Services
6) Please rate the importance of the following INNOVATIVE features in dental practice management software, on a scale of 1 to 5 (1 being not important, 5 being very important):
    a) Online Appointment Booking
    b) Automated appointment reminders, treatment plan notifications
    c) Integration with digital imaging tools to capture and analyze X-rays, intraoral scans, and 3D models
    d) Electronic Health Records (EHR)
    e) Integration with Digital Treatment Tools: intraoral cameras, CAD/CAM systems, and digital scanners
    f) Automated Billing and Insurance Claims
    g) Tools for collecting patient feedback and online reviews
    h) Mobile Accessibility
    i) Patient Education Resources
    j) Automated Insurance Verification and Claims
    k) IoT Integration for Dental Equipment (supplies records)
    l) Predictive Analytics for Inventory Management
    m) Gamification for Pediatric Patients
    n) Multilingual Support
7) How satisfied are you with your current dental practice management software?
    a) Very satisfied
    b) Satisfied
    c) Neutral
    d) Dissatisfied
    e) Very dissatisfied

8) What are the primary reasons for your satisfaction/dissatisfaction with the current software?
9) How would you rate the ease of use of your current dental practice management software?
    a) Very easy
    b) Easy
    c) Neutral
    d) Difficult
    e) Very difficult
10) What specific aspects of the software contribute to its ease or difficulty of use?
11) Have you received sufficient training and support to effectively use the current software?
    a) Yes, adequate training and support
    b) Yes, but insufficient training and support
    c) No, I did not receive any training or support
12) How could the software vendor improve their training and support services?
13) How confident are you in the data security and privacy measures of your current software vendor?
    a) Very confident
    b) Confident
    c) Neutral
    d) Not very confident
    e) Not confident at all
14) What are the top three features or functionalities you wish your current software had?
15) What are the main areas for improvement that you would like to see in your current dental practice management software?
16) Would you consider switching to a new dental practice management software?
    a) Yes, definitely
    b) Yes, maybe
    c) No, not at the moment
17) What factors would influence your decision to switch software vendors?
18) An open-ended field for any additional comments, suggestions, or concerns you have.

Interview method

Comprehensive interviews were conducted with the owner of the Smile House clinic, Maria, and the business manager of the Coradent clinic, Diego, both located in the city of Valencia, regarding the effectiveness of the current and previously used software and their proposals for its improvement. The opinion provided by the interviewees regarding the software and possible options for improvements was based on the following open-ended questions:

1) Could you please introduce yourself and provide a brief overview of your dental practice? How long have you been practicing, and what motivated you to enter the field of dentistry?
2) Can you describe the dental practice management software that you currently use or have used in the past? What led you to choose this particular software?
3) How has the software impacted your daily operations and overall practice management? What were the main challenges it helped you address?
4) Could you share specific examples of how the software has improved the efficiency of tasks like appointment scheduling, patient records management, billing, and treatment planning?
5) Which features of the software do you find most valuable and essential for your practice's smooth operation? Are there any specific features that stand out as particularly beneficial?
6) Have you encountered any limitations or gaps in the software's features that you believe could be improved upon? Are there functionalities that you wish the software offered but currently does not?
7) How would you describe the user-friendliness of the software's interface? Is the software intuitive for both you and your staff, or have there been challenges in adapting to its use?
8) Can you provide examples of instances where the software's user interface design or navigation positively or negatively impacted your workflow?
9) Does the software integrate well with other systems or technologies used in your dental practice, such as imaging software, or communication tools?
10) Based on your experience, are there specific areas where you believe the software could be improved to better meet the needs of dental practices?
11) How responsive and effective is the customer support provided by the software vendor in addressing your concerns or technical issues?
12) Given the sensitive nature of patient data in the dental field, how confident are you in the software's security measures and data protection protocols?

13) How open are you to adopting new technologies or features as they become available? Are there specific innovations you are particularly excited about?
14) In summary, how would you describe the overall impact of dental practice management software on your practice's efficiency, patient care, and business operations?
15) Is there any additional information or insights you would like to share about your experience with dental practice management software?

The answers to the interviews and the questionnaire became the basis of the research and the formation of proposals for improving software in dental clinics.

Statistical method

The statistical method was used to analyze the results of the questionnaire and the obtained data from the respondents.

So, based on the methods described above, improvement proposals for the software in dental clinics were made. The application of these methods in the course of the study allowed to obtain enough information to form conclusions.

3.2. Choice of variables

In conducting a comprehensive study to analyze and evaluate existing dental practice management software, several methodological considerations should be taken into account. These considerations ensure that the study is rigorous, reliable, and provides meaningful insights. To conduct a comprehensive analysis, the following variables were defined:

1. **Price**. This variable refers to the cost of the dental practice management software, including any subscription fees, licensing fees, or additional charges.
2. **Usability**. This variable assesses the ease of use and user-friendliness of the software. It includes factors such as the interface's intuitiveness, navigation, and overall user experience. The repeated scenario of inputting patient data and scheduling an appointment was used to analyze selected programs with this criteria. The approximate actions performed in this scenario are the following. Upon logging in, the software's

dashboard provides access to various functions. Moving to the patient section, the input of patient information like contact details and medical history is available. Navigating to appointments within the patient's profile, a suitable date and time was chosen from a calendar tool, specifying the appointment type. After confirming the details, the software sends confirmation messages and automated reminders as the appointment approaches.

3. **Functions.** This variable evaluates the range and effectiveness of the features and functionalities offered by the software. It includes modules for appointment scheduling, patient records management, billing and invoicing, treatment planning, and other relevant functions.
4. **Availability**. This variable examines the accessibility and availability of the software. It includes considerations such as compatibility with different operating systems, devices (desktop, mobile), and internet connectivity requirements.
5. **Requirements for technical knowledge**. This variable assesses the level of technical expertise needed to operate and manage the software effectively. It includes considerations such as the learning curve, training requirements, and technical support available.
6. **Integration capabilities**. This variable evaluates the software's ability to integrate with other systems and technologies commonly used in dental practices. It includes considerations like interoperability with imaging systems, dental CAD/CAM software, Electronic Health Records (EHRs), or third-party billing systems.
7. **Security and compliance**. This variable examines the software's security measures and compliance with relevant data protection and privacy regulations. It includes data encryption, access controls, backup and recovery procedures, and adherence to HIPAA regulations.
8. **Customer support.** This variable assesses the quality and effectiveness of the software company's customer support services. It includes considerations such as the availability of support channels (phone, email, live chat), response time, resolution of issues, and user satisfaction with the support provided.

4. RESEARCH RESULTS

4.1. Conducting a questionnaire and an interview to obtain opinions and impressions from dental practice management systems users

The data collection database was created due to research among Spanish dental clinics and listing them. As a result, 350 questionnaires were sent to dental facilities to survey dentists, clinic owners, and staff. In total, 33 valid responses were received, excluding incomplete questionnaires, representing 9,4% of the expected quantity. Thus, a sample of 33 people, 55,4% of whom are dentists, 27,3% - dental clinic staff, and 18,2% - dental clinic owners was formed to survey the chosen topic. The clinics mentioned by the respondents are located in cities such as Madrid, Valencia, Barcelona, Bilbao, Alicante, Valterna, and others. The study was conducted online in June-July 2023.

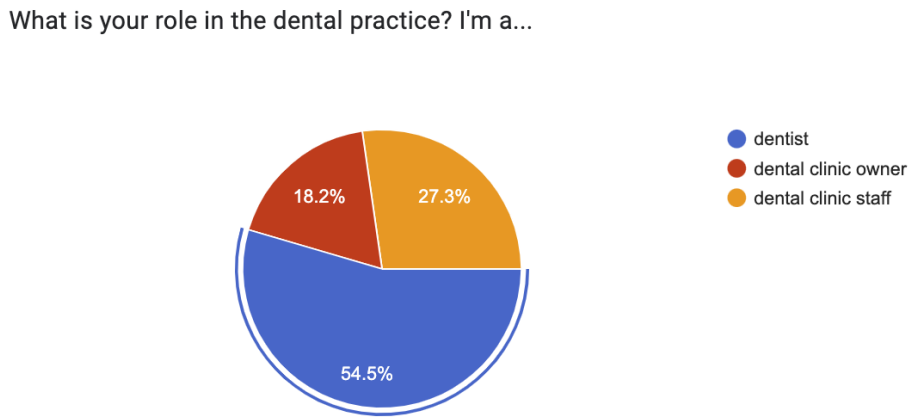

Figure 5. Characteristics of the respondents: their role in dental practice (made by the author)

Summarizing the results, the most used dental management software by the respondents are:

- Gesden G5 (with nine answers);
- Aquar software (with seven answers);
- EasyClinic (with five answers);
- PracticeDent (with four answers).

Other answers included the following software: Gesden One, Dental Soft, Dentrix, and others, which were not selected for further analysis due to the low number of choices of these programs.

Also, the study allows to point out the following statistics:

Question	Options	%
How satisfied are you with your current dental practice management software?	Very satisfied	**0**
	Satisfied	**9,1**
	Neutral	**18,2**
	Dissatisfied	**45,5**
	Very dissatisfied	**27,3**
How would you rate the ease of use of your current dental practice management software?	Very easy	**12,5**
	Easy	**12,5**
	Neutral	**12,5**
	Difficult	**62,5**
	Very difficult	**0**
Have you received sufficient training and support to effectively use the current software?	Yes, adequate training and support	**11,1**
	Yes, but insufficient training and support	**66,7**
	No, I did not receive any training or support	**22,2**
How confident are you in the data security and privacy measures of your current software vendor?	Very confident	**0**
	Confident	**50**
	Neutral	**37,5**
	Not very confident	**12,5**
	Not confident at all	**0**
Would you consider switching to a new dental practice management software?	Yes, definitely	**62,5**
	Yes, maybe	**25**
	No, not at the moment	**12,5**

Table 4. Statistics of the questionnaire's answers (made by the author)

Most respondents are dissatisfied with the currently used software: 45,5% are dissatisfied, while 27,3% are very dissatisfied. Only 9,1% are satisfied with their customer's experience, and 18,2% have a neutral opinion. The primary reasons for their satisfaction or dissatisfaction with the current software were a non-user-friendly interface, unpleasant aesthetic appearance, difficulties

manipulating the program, poor integration with other essential tools and software, and lack of technical support on the developers' side.

The ease of use of current dental practice management software is defined as difficult by 62,5% of interviewees. Other 37,5% chose options "very easy", "easy", or "neutral". As specific aspects of the software that contribute to its ease or difficulty of use, the respondents mentioned interface and dashboard design and prompt support via phone, chat, or e-mail.

77,8% of the interviewees confirm they received sufficient training and support to effectively use the current software, although only 11,1% signify it as adequate. Other 66,7% say it was insufficient, and 22,2% did not receive any training or support. Typical answers to the additional question "How could the software vendor improve their training and support services?" were suggestions to implement educational webinars, in-office training, support via video chat in the customer's language, and synchronized training for all personnel.

Regarding the security of the currently used software, 50% of the respondents are confident about privacy measures, 37,5% chose the option "neutral", and 12,5% are not very confident with the current software vendor's data security.

Among the top three features or functionalities the interviewees wish their current software had are interactive and user-friendly interface design, high data security, automatized communication with existing and potential patients, integration of Microsoft Office and tools like PowerBI for data analysis, digital records with patients' photos, X-ray-scans etc.

As the main areas for improvement in the current dental practice management software, the respondents mentioned the following: reporting, analytics and data management, financial and administrative areas, User Interface (UI) design, and the software's performance speed.

Most of the interviewees (87,5%) are considering switching to a new dental practice management software. They also mentioned factors that would influence the decision to switch software vendors. These are the ease of user experience, UI design, and software price.

Based on the survey results, the following conclusions can be drawn: most respondents are dissatisfied with their current dental practice management system and are considering switching to another one. Among the common reasons for dissatisfaction are:

- Poorly designed and structured interface that complicates the general use of the software;
- Lack of tools for reporting and analytics, unavailability to issue advanced reports;
- Absence of useful integrations with other programs such as Microsoft Office, imaging systems, etc.;
- Insufficient training on how to use the software and lack of technical support on the developers' side after purchase;
- Overall, the unpleasant appearance of the software.

According to the questionnaire results, the following features in dental practice management software are rated as most important for dentists, clinic owners, and staff.

Area	Description
Appointment scheduling	Efficient appointment scheduling and management capabilities are essential for dental clinics. The software should allow easy scheduling of appointments, provide reminders to patients, and enable rescheduling or cancellations. It should also have a centralized view of the clinic's schedule, allowing staff members to efficiently manage and optimize appointment slots.
Patient records management	Allowing the capture, organization, and storage of patient data, including medical histories, diagnostic results, treatment plans, and medication records.
Reporting and analytics	The ability to generate comprehensive reports on various metrics, such as financial performance, treatment patterns, and patient demographics. Advanced analytics can provide valuable insights for optimizing clinic operations and making data-driven decisions.
Cloud and back-up services	Allowing regular back-ups to ensure the protection of patient information or storing all the clinic's data on the online protected server.

Finances	Billing, invoicing, and integration of the accounting system. Effective billing and financial management features are crucial for dental clinics to streamline revenue collection and track financial performance. The software should support accurate billing, insurance claims management, and patient payment processing. It should also provide financial reports and analytics to help clinics monitor their revenue, track outstanding balances, and manage expenses.
Integrations	Integration with imaging and X-ray systems. Seamless integration with other systems and technologies used in dental clinics, such as imaging equipment to capture and analyze X-rays and intraoral scans.

Table 5. The most important features in dental practice management software by respondents' opinion (made by the author)

Also, respondents defined several areas for improvement and innovative features or functionalities they would like to implement in current dental practice management software. These include:

Area	Description
Communication	Automated appointment reminders and treatment plan notifications for better communication with existing and potential patients
Integrations	Integration with digital imaging tools to capture and analyze X-rays, intraoral scans, and 3D models. Integration with digital treatment tools – intraoral cameras, CAD/CAM systems, and digital scanners.
Electronic Health Records (EHRs)	Extended patient profiles containing demographic data, contact information, restorative and periodontal status, treatment plans, X-ray images, scans, and files;
Mobile accessibility	Allowing access to patient records, schedule appointments, and manage clinic operations from anywhere, enhancing flexibility and productivity.

Table 6. Areas for improvement in dental practice management software defined by respondents (made by the author)

The next part of the research included interviewing the Smile House dental clinic's owner, Maria, and the business manager of the Coradent dental clinic, Diego, located in Valencia, Spain. Their answers play a crucial role in the empirical part of the research. The analysis of the obtained data

impacted the study's conclusions and proposals for improving software in dental clinics. Below, the results of the conducted interviews are described.

INTERVIEW A:

Maria is the owner of the Smile House clinic. She has been practicing dentistry for 23 years and is fully dedicated to her profession. During the interview, Maria shared her experience with dental management software. She mentioned that she has been using different software solutions for several years to manage various aspects of her practice, including appointment scheduling, patient records, billing, and inventory management. The owner mentioned that the software has helped her reduce paperwork and manual data entry. However, the owner also highlighted some challenges she has faced: after several attempts to switch software, she still needs help finding one that meets the clinic's needs. Below, the conducted interview and the conclusions that can be drawn are briefly outlined.

The first software to be implemented in the management system of the clinic was the Aquar Software. The main reason for her dissatisfaction with the said program is the missing data backup on a secure server and data recovery procedures. Due to such flaws and personnel incompetence, Maria lost all of her data with no possibility of restoration.

Next, the owner switched to Gesden G5 software, which is still used today. Maria points out the following reasons why this system is unsuitable for her dental practice.

Firstly, the inability to define different levels of permissions and accesses. As discovered in the next part of the research, this feature is available only beginning from the Gesden G5 Profesional plan, which is suitable for clinics with four to six computers. Since Maria's clinic uses fewer computers, she opted for a different purchase plan. This situation indicates that the Gesden G5 is limiting smaller clinics or clinics with fewer computers in functionality, which is essential regardless of clinic size.

Secondly, she mentioned the inability of the administrator or clinic owner to correct data entry errors or edit performed procedures information that was previously entered by clinic staff.

During the interview, the owner of Smile House clinic in Valencia expressed her interest in switching to a different dental management software. She mentioned that she has explored various options and has narrowed down her choices based on their specific needs and requirements. Specifically, she is considering switching to EasyClinic software, which is said to be visually pleasant, while Gesden G5 is "optically intoxicating". She emphasized the importance of a user-friendly interface that is intuitive and easy for staff members. Maria cites the following as an example of a shortcoming in the area of interface design and user experience. In the calendar, there is an opportunity to schedule an appointment with a client for 15 minutes only. In case the procedure lasts, for instance, one hour, in the schedule, this record looks like four different appointments of 15 minutes each with the client's name repeated.

Lastly, in the mentioned program, Maria lacks customization. She points out that customizing the design of the software interface would positively affect the clinic's brand. For example, if there was a function to change the software's company logo to the clinic's logo. Alternatively, a function to assign a particular color to each doctor and each type of procedure or to change the interface's colors in general.

Overall, the owner is looking for dental management software that addresses the limitations she has experienced with her current software. She wants a solution that offers improved performance, a user-friendly interface, customization options, and seamless integration with other systems. According to Maria's opinion, several components are crucial for satisfactory dental management software. These include:

Area	Description
Training and support	Adequate training and ongoing support from the software vendor are crucial for successfully implementing and using the software. This may include comprehensive training resources, responsive customer support, and regular software updates to address issues and improve functionality.
Access management	Advanced access management to define multiple levels of permissions for dental owners, dentists or staff is one of the vital functions.

Mobile accessibility	The ability to operate processes from a mobile phone or tablet would be a valuable addition to the functionality, enhancing usability and not requiring constant access to a computer and the program installed on it.
User-friendly interface	A user-friendly interface is essential for efficient navigation and utilization of the software. It should be easy to understand, reducing the learning curve for both new and existing staff members. Also, an intuitive interface is essential for stable performance and smooth operations.
Customization	The ability to customize the software to match the clinic's specific needs and preferences is highly valued. This includes customizing workflows, templates, logos, and features to align with the clinic's unique processes and requirements.
Integrations	Seamless integration with other systems and technologies used in the clinic, such as digital imaging equipment and patient communication tools, is important. This integration enhances workflow efficiency and ensures smooth data transfer between different systems.
Data Analytics	The software should provide robust reporting and analytics capabilities, allowing the clinic to generate detailed reports on various metrics. This data-driven insight helps in making informed decisions, improving patient care, and optimizing clinic operations.
Data Security	The software should be reliable and provide high data security, including backup services.

Table 7. Results of the profound interview A: Crucial components for a satisfactory dental practice management software (made by the author)

Considering these components, dental management software can provide a satisfactory experience for clinic owners, staff members, and patients.

Regarding future technologies in the dental practice, Maria does not foresee the implementation of tele-dentistry, artificial intelligence, and other innovations. On the contrary, she prefers developers to enhance existing solutions instead of new integrations. The owner does not see the value in bringing innovative technologies as long as areas such as patient records, appointment scheduling, financial accounting, or the overall interface of the software, which are considered to be fundamental features for this type of software, require improvement and do not meet the clinics' needs for increased efficiency, increased operational simplicity and time savings.

INTERVIEW B:

Diego is a business administrator in his parents' Coradent dental clinic, which opened in Valencia five years ago. He currently operates in the back office: supports the commercial-administrative flow, creates digital content and ideas for improvement, manages planning, and conducts data analysis and reports. Apart from being a family business, Diego considers dentistry as a really rewarding industry when it comes to patient treatment results, which motivates him.

In the Coradent clinic, the installed software is PracticeDent, which includes modules like a control panel, invoicing, CRM, calendar, inventory management, and some marketing tools. Diego mentions that he and his parents are satisfied with their program choice due to the following factors: affordability, Cloud data storage, and easy-to-understand dashboard. He points out the following examples of how the software has improved the efficiency and overall clinic performance:

- With a few clicks, he and his parents can schedule an appointment and check on the agenda for the week, month, and even year. The software has a feature that enables visualization of the daily schedule for each dentist, with information like the patient's name and the appointment status. Specifically, it is helpful for dentists, as some of them do not have a fixed schedule;
- The software provides crucial information to recall before a visit or a treatment, like the patient's anamnesis, current treatment plan, emergencies, or canceled appointments;
- PracticeDent comprises all the patient's data, simplifying and streamlining communication as well as has features providing communication with a group of patients;
- The software integrates well with imaging systems, specifically with the results of the X-rays;
- The advanced management feature offers that every operation, update, or change in the information or the software is recorded to know who, when, and what was updated.

Among the main challenges the software helped to address are the organization of daily agenda and operations, issuing invoices, and managing finances. As the most valuable and essential for the practice's smooth operation, Diego finds the automatic generation of reports and histograms shown in one tab as well as simple and interpretable graphics. According to his opinion,

PracticeDent is easy to understand and to use for all the staff. It did not require training before being implemented.

However, Diego mentions that the software implementation could have impacted their daily operations and overall practice management a lot more. Although the software includes basic features, the clinic professionals do not get the most out of its functionality. It is mainly used for scheduling appointments and managing information related to the patient's clinic history. Operating the program, they have encountered some limitations in the software's features that could be improved. These include:

- PracticeDent needs to offer more options for data export. The clinic's staff cannot withdraw information on their patients' to Microsoft Office or SQL for further analysis. Diego needed to export information to Excel. That required him to contact the developers of the software and demand that information in a file;
- The CRM module could be more organized and simplified as well. It cannot automatize communications with patients and data export options;
- The software does not provide an online appointment booking option for the patients.

In addition, Diego finds customer support provided by the software vendor in addressing concerns or technical issues quite time-consuming and complicated since the developers are based in a foreign language-speaking country. There is no possibility to contact support directly, so he had to do an extensive investigation to get in touch with them. He and his parents have not had many concerns or technical issues with the product, but the communication process is difficult when they do. Also, he outlines his uncertainty with the software's data security and protection.

Diego is highly open to adopting new technologies as long as they are affordable and easy to implement and use. He foresees how AI and Robotics can affect the industry as well as the following emerging trends and advancements in dental practice management software, such as:

- The ability to implement Artificial Intelligence for advanced data-driven insights and revolutionizing dental diagnostics, treatment planning, and prediction making, therefore increasing the trust within the patient;
- Integration of a self-operational and virtual value chain that automatically contacts suppliers when low in stocks or when a particular product's demand increases.

Regarding the overall impact of dental practice management software on the practice's efficiency, patient care, and business operations, Diego mentions that along with the dentists and equipment, it is the most essential asset for a dental clinic. Its value comes from the ability to automate processes and increase efficiency, organization, and accessibility to a vast data amount. With robust software availability, it is possible to grow business and provide critical insights, graphs, and tools to make planning and decision-making processes more straightforward.

4.2. Analysis of the functionality and use of software in dental clinics

A total of six programs were selected for in-depth analysis. Below, the list of software is defined and analyzed, and the rationale behind the choices is explained.

Gesden G5, Aquar Software, EasyClinic, PracticeDent — the most frequently encountered softwares in the answers to the question "Which dental practice management software do you currently use?" in the survey.
CliniWin — a local developer of this type of software (Alboraya, Comunidad Valenciana).
PerioSystem — a French software sponsored by the European Union and mentioned as introducing four significant technological advances to clinical dentistry.

Below, a detailed comparative analysis of the software is provided in accordance with the variables described in the previous part of the thesis: price, usability, functions, availability, requirements for technical knowledge, security and compliance, and customer support.

4.2.1. GESDEN G5

— practice management software by Henry Chein company. Gesden offers the management of patient records and integration with diagnostic imaging systems. It includes all the economic, administrative, communication, and marketing management tools. It is designed for the integral management of the clinic.

Price:

Prices are not listed on the developer's website. Moreover, the managers did not provide the pricelist after submitting an email request. Therefore, the information that was managed to be obtained is indicated further. Before purchasing the software, it is required to choose an appropriate plan, which depends on the number of computers connected to it. There are four purchase plans available: Gesden G5 Easy (connects up to 3 computers), Gesden G5 Professional (connects up to 6 computers), Gesden G5 Large Clinics (connects up to 7 computers), and Gesden G5 Multicentre (connects unlimited number of computers).

The price includes the expenses of installation, transport, and insurance until the delivery of the product. Once the installation of the software is completed, both parties sign a mandatory Maintenance contract during the first year, according to which the seller will provide, in exchange for a previously stipulated monthly amount, an assistance service that will cover the services inherent to the technological support of the software; maintenance, updates, and the technical assistance required for the proper operation of the purchased software. The software is guaranteed for six months. This warranty does not cover the repair of errors caused by negligence or misuse, an incorrect shutdown of the computer, or due to failures and voltage peaks in the electrical power supply.

Usability:

The following was identified by performing the scenario mentioned earlier to evaluate this variable. Since Gesden G5 does not provide a demo or trial version of its software, the request was sent to the owner of Smile House Clinic, who was interviewed previously, to grant access to the system and perform the test. It took 5 minutes and 20 seconds to run the scenario. After its conclusion, the interface issues mentioned in the interview by Maria were encountered, more precisely, the inability to specify the duration of the patient visit, which is limited by the program to 15 minutes. No other difficulties were noticed, but it should be noted that the software has a complicated and poorly structured interface design, which complicates the overall use of the program, especially for inexperienced users.

Functions:

The features listed below are accessible according to the chosen purchase plan.

- Patient records:
    - Patient management, belonging to and accessible from a clinic and/or from all the clinics;
    - History with Odontogram;
    - Single-User Agenda.
- Multi-Clinic Agenda:

*Multi-Center Agenda, unified management of all the clinics' offices. Definition of different levels of permissions and accesses. Allows the creation of a Call Center for managing all the agendas in a group.

- User-customizable work screen;
- Automatic Budgets;
- Complete collection circuit (invoices, collections, advances, cancellation of collections, etc.);
- Assistance for invoicing and settlement of mutual insurance companies;

*Same assistant per clinic or general group.

- Configurable lists (patients, pending, historical clients, mutual companies, collections, production, official income lists, income list 347, list of treatment credits);
- Configurable lists (more than 150 different lists);

*Allows obtaining reports by a clinic or grouping of the clinics the user indicates, according to the defined security levels.

- Invoices and receipts are automatically integrated with accounting;
- Reminder system for upcoming visits;
- Economic plans for financial specialists;
- Consulting for comparative studies (production, income, work time, patient flow, expense graph, profit graph, etc.);

*Allows obtaining reports by a clinic or grouping of the Clinics that the user indicates, according to the defined security levels.

- Creation of patient cards;
- Control of expenses, suppliers, warehouses, orders, and banks;
- Multi-center and Multistore product management, allowing unified management of the entire group of clinics and/or management of products by a clinic;

- Sending to prosthetists;
- Sending invoices and budgets by email;
- Issuing prescriptions;
- Basic orthodontic record;
- Periodontogram with comparative evolution;
- Registration of accesses to the program.

Availability:

Integrating such modules as Remote Access, Agenda Online, and Mobile Devices is possible, which allows clinic professionals to view but not access or edit Gesden's Agenda from any mobile device with an Internet connection.

Cross-platform:

The software is available only on desktop computers with Windows operating systems.

Requirements for technical knowledge:

The company regularly conducts webinars and workshops and has 49 video tutorials on using the software to improve the customer experience. Nevertheless, no special technical knowledge is required.

Integration capabilities:

The software integrates or/and cooperates with:

- Outlook;
- Informed Consent Program of the Board;
- Allows integration with all imaging systems (with additional cost);
- The company's different software and modules such as:
    - Software Gesimag – image acquisition and processing software;
    - Software Ortomed – a cephalometric analysis software for the diagnostics and planning of orthodontic cases;
    - Software Didactic – an interactive software for the presentation of clinical cases through high-definition 3D animations, which improves communication with the patient and increases treatment acceptance;

- SMS and emailing modules – modules for the automated sending of SMS and email messages from Gesden's agenda and list of recalls;
- Clinipad module – a software designed for the digital signature of documents and communication with the patients;
- Check-in module – an app to optimize the management of patient's arrival at the clinic, freeing up the reception and organizing the entry of patients;
- Check-out module – an app for evaluating patient satisfaction through a brief survey when leaving the clinic about the service received;
- Control Panel module – a real-time representation of the clinic's results through dynamic graphs that help to analyze the clinic's performance in terms of expenses, incomes, profits, rentability, quality of service, etc;
- Online Backup Module – a software for remote data backup on a secure server. It is a fully automatic system and confidentiality based on Microsoft Azure Backup technology;
- Remote Access, Agenda Online, and Mobile Devices – modules that allow clinic professionals to access Gesden's Agenda from any mobile device, tablet, or smartphone with an Internet connection;
- Accounting Export and Automatic Invoicing modules – for automating accounting systems.

Security and compliance:

The software is adapted to the new General Data Protection Regulation EU 2016/679.

Customer support:

Customer support is conducted daily by 45 professionals via the phone.

Testimonials:

For the given software, no reviews from real customers were found. The only opinions available on the Internet are those listed on the company's website, the objectivity of which cannot be confirmed or guaranteed. Fortunately, there was an opportunity to interview the owner of a dental clinic and a dentist. Previously, as mentioned, the data obtained during the interview and Maria's dissatisfaction with this software.

4.2.2. AQUAR SOFTWARE

— dental software for the complete management of dental centers.

Price:

The purchase is made through a single payment starting at 160 euros per module, such as: Agenda, Clients | Patients, Sales, Purchases, Reception, Work Sheet, Warehouse. Moreover, per service, such as External Connection, Aquar Mobile, Sending SMS, Whatsapp, and Electronic Prescription. A 1-year warranty and 1-year assistance are included in the purchase price of the software.

Usability:

The following was identified by performing the scenario mentioned earlier to evaluate this criterion. Aquar Software also does not provide a demo or trial version of its software. To resolve this problem and perform system testing, Maria, the clinic owner, was contacted since, as indicated earlier in the interview results - her clinic had been using this program before switching to Gesden G5, and it remained installed on the previously used computer. Conducting the scenario took almost 5 minutes. Despite performing the required actions successfully, the time of the completion and performance, in general, were negatively affected by the overloaded and outdated design of the software interface, or more precisely, by the overabundance of details and unnecessary (optional) fields to fill in.

Functions:

- Advanced Multi-Agenda;
- Budget, Sales Documents, Billing, Financing, Expense Control, Partnerships and Agreements Reports, Charts, Automatic Invoicing, including control of economic percentages for collaborators, associates, and Comprehensive treatment voucher management;
- Workflow management for mutual and insurance companies, fully configurable;
- Complete Patient Data Management;
- Digital Consents;
- Patient Classification;
- Inventory Control;
- Reception;

- Laboratory records keeping;
- Worksheet;
- Documents Management;
- Medical Examinations;
- Access permissions and restrictions;
- Electronic Official Prescription to create official electronic prescriptions from preconfigured templates to streamline the facility's workflow;
- Management of commissions to professionals;
- Image management;
- Appointment reminders, birthday greetings, review reminders, promotions, sending invoices, and quotations via SMS, WhatsApp, or email.

Availability:

An Internet connection is not required to use the software. However, it is necessary when performing initial installation, conducting a training course, if technical assistance is required, or when using services such as sending texts via SMS, WhatsApp, or email.

Cross-platform:

Compatible from Windows XP with SP3 to Windows 10. Compatible from MacOS 10.7 to MacOS 10.11. Offers to use a tablet (iPadOS or Android) that allows patients to fill in their data, show images, and interact with them. It also allows access to all the information and functionality of the application. Applications are installed on the client's equipment.

Requirements for technical knowledge:

The software purchase includes a training course and a manual to explain the workflow and functionality. During the warranty period, the software's support promises to help if any problems occur.

Integration capabilities:

The software is compatible with external software – for example, synchronization of the leading RX Systems (more than 20 available).

Security and compliance:

In addition to the security protocols under the strictest standards offered by systems, applications allow greater control and security at the data type level. This security allows restricting or authorizing a user to work with certain records of the same data catalog, keeping a record of access and modifying user actions. All applications are installed in the client's equipment, thus increasing security and reducing the risk of unwanted access.

In compliance with the Organic Law 15/1999 of December 13 for the Protection of Personal Data (L.O.P.D.). Aquar Software complies with all the high-level requirements. Administrators are given the ability to restrict personnel access to various modules of the software.

Customer support:

Customer support is conducted daily via email and phone. One year of assistance is included in the purchase.

Testimonials:

Only one review of the mentioned software was available. Nallhira Figueredo wrote about her unsatisfactory experience using it: she wanted more than the quality of the training and the absence of the promised assistance and warranty.

4.2.3. CLINIWIN

— is the multiplatform and cloud-based management Spanish program created to manage a dental clinic's information and is continuously improved with the customers' suggestions.

Price:

The company offers three types of purchasing plans.

Free: It is possible to use the program free of charge for three months. The tariff includes basic training on the program's functionality and support.

Annual subscription: 49.5 euros per month. In addition to the access to the software, the purchase includes data transfer from the previously used software, one year of free use of CliniTime (Cliniwin's program which records the schedule of each employee from browser, tablet, etc.), regular software updates, training, and didactic support.

Premium rate: The price is calculated individually for each request. In addition to access to the software, the purchase comes with all the previously mentioned features: premium support, unlimited cloud space, SMS, WhatsApp, and mail notification functions, integration with digital radiology, and a biometric digital signature function.

Usability:

A demo version of the software from the development company was requested to perform the previously mentioned scenario for evaluating this criterion. The test took 3 minutes and 40 seconds due to the comprehensible dashboard. In general, there were no difficulties experienced with this process. As in the previously reviewed software, the scenario execution time and the overall impression of working with the program could be optimized by improving the interface design. The visual concept of the program needs to be updated compared to its competitors and degrades the user experience.

Functions:

- Transferring the data from previously used programs;
- Accessing data at any time and any place;
- Setting schedules and access permissions;
- Medical management:
    - Control of personal data, charges, and treatments with all the information centralized in a file: clinical history, budgets, prescriptions, approvals;
    - Keeping track of the dental clinic's specialties: orthodontics, periodontics, implants, prosthetics;
    - Digitally signing documents and attaching photos or videos;
    - Connecting digital radiology;
    - Exporting data to PDF or Excel;
    - Patient records: treatment history and charges.
- Economical management:
    - Control the clinic's incomes, expenses, and commissions with all the information available to draw customizable statistics and consult the control of production, debts;
    - Issuing invoices and exporting all the data;

        - Calculating the doctors' commissions, creating several billing lines, closing cash drawers to record the income, notifying the debts.
- Marketing management:
    - Contacting patients: sending notifications by WhatsApp, SMS, or Email in the patient's language;
    - Notifications for birthdays, appointments, and check-up reminders;
    - Sending quotes or invoices, sending mass mailings, reminding a debt;
    - Making and confirming appointments online by Whatsapp, SMS, or email in several languages.

Availability & Cross-platform:

It works on any device and has automatic backups that are downloadable anytime.

Requirements for technical knowledge:

The software purchase includes a training course, though no technical knowledge is required.

Integration capabilities:

The software offers integration with digital radiology and CliniTime.

Security and compliance:

The company guarantees compliance with current regulations on personal data protection, reflected in the Organic Law 3/2018 of December 5 on the Protection of Personal Data and Guarantee of Digital Rights (LOPD GDD). It also complies with European Union regulation on Information privacy in the European Union (EU) and the European Economic Area (EEA) (GDPR).

Customer support:

The development team maintains constant contact with users, taking note of their suggestions and continually incorporating new features and improvements. Thus, 2521 users' suggestions were added to Cliniwin.

Testimonials:

There are six reviews on Google with an average estimation of 4 points out of 5. The following benefits of the software were cited: reporting system, visually simple agenda and database, accounting system, issuing invoices, and technical support.

4.2.4. EASYCLINIC

— EMR & clinic management software for doctors and clinics.

Price:

The company offers three types of purchasing plans.

a) Professional — 16,7€ per month per user.

This plan includes the following features: patient management, Electronic Medical Records (EMR), finance, billing and payments, appointment scheduling, dashboard and reports, Free Support and Training, and Reception user.

b) Premium — 20€ per month per user.

In addition to access to the software, the purchase comes with all the previously mentioned features, as well as electronic medical records (EMR) advanced with specialist modules, chronic care management and patient engagement, virtual clinic - video consultation and online payments, detailed dashboards, analysis & reports, custom examination forms and printouts, lab reporting, dedicated account manager.

c) Enterprise — custom price for each request.

It is a cloud medical ERP solution for medium to large healthcare organizations. It offers over 20 modules covering all aspects of patient management, scheduling, finance, CRM, medical records, inventory, insurance, patient portal, lab, radiology, IVR, and more.

When choosing an annual subscription, the company offers a 20% off discount.

Usability:

A demo version of the software from the development company was requested to perform the previously mentioned scenario for evaluating this criterion. Conducting the test scenario took two minutes. Due to not being frequent users of this type of software, it is assumed that for medical clinic personnel, setting up a patient appointment and filling in the patient's personal information

could take a significantly lower amount of time with practice. The conclusion is drawn based on the user-friendly design of the software's interface and intuitiveness.

Functions:

- Electronic medical records (EMR):
    - A comprehensive view of a patient's clinical summary;
    - Recording case notes;
    - Creating, printing, and sending prescriptions via email or WhatsApp;
    - Effective management of patient follow-ups.
- Appointment scheduling:
    - Booking appointments, automating patient reminders, and managing a doctor's day efficiently;
    - Creating automated reminders and following up with patients;
    - Online appointments and fee collection.
- Finance & Accounting:
    - Invoicing patients, managing outstanding's, collecting online payments, and viewing financial reports;
    - Maintaining strict control over financial transactions and a complete audit trail of all activities.
- Inventory & Pharmacy Management:
    - Strict control and audit trails that is in-built along with reports that give an in-depth analysis of the inventory in real-time;
    - Fully integrated pharmacy - fully equipped to handle in-house or walk-in patients with outside prescriptions.
- Lab & Radiology Management:
    - Reports can be entered directly into the patient's medical record as images, text/pdf files as well as structured data for comparison;
    - Ability to upload reports through the portal delivered directly to patients or clinic owners.
- Communication – SMS, Email:
    - Communicating with patients, referral doctors, third-party providers, suppliers, and internal staff via automated SMS and emails;

        - Setting up message templates and defining the events for automation.
- Analysis & Reporting;
- Business Development:
    - Customer relationship management;
    - Patient Portal to access their health records online, request appointments, medication refills, and update health status, history, and demographics.
- Creation of customized printouts.

Availability:

There are software versions to suit any healthcare practice, whether an individual doctor's practice, a multi-user polyclinic, or a chain of clinics.

Cross-platform:

Compatible with all device types and operating systems.

Requirements for technical knowledge:

No technical knowledge is required. There is no information on the software website whether a training course is included in the purchase.

Integration capabilities:

The software offers to interface and integrate with almost all hardware and software using HL7 or direct API integration.

Security and compliance:

It is stated that Easy Clinic is built on the latest modern technology, includes industry-leading encryption standards, and gives 100% bank-level security. Giving users different access levels based on their organizational roles is possible.

Customer support:

The company provides customers with a support team via phone, email, and chat.

Testimonials:

For selected software, a few reviews were available. Most are listed on the company's website. Therefore, the objectiveness of the information provided cannot be assured. These testimonials highlight the software's support, user-friendliness, UI design, data input, prescription management, and unified system. Another two feedbacks were found on the Indiamart website outlining the software's general ease of use and support system, clinical research, accounts, images, and immunization.

4.2.5. PRACTICEDENT

Price:

A monthly fee is 35€, billed quarterly. The software can be used for one month for free. Advanced functions, e.g., expanded patient profiles, expanded finance module, and expanded plannings, are on-demand additions or so-called in-app purchases.

Usability:

Conducting the test scenario took three and a half minutes. The software offers a user-friendly calendar interface, allowing swiftly navigate through dates and available time slots, which are color-coded for different appointment types. The system promptly sent out confirmation notifications as the user confirmed the appointment. Overall, the usability was intuitive, yet designing the interface in a more up-to-date and mobile-friendly way is recommended.

Functions:

- Scheduling tool: multi-person events, appointment statuses, SMS confirmations, and notes;
- Electronic Health Record (EHR): extended patient profile containing demographic data, contact information, restorative and periodontal status, treatment plans, X-ray images, scans, and files;
- The Control Room: a dashboard with the entire staff's calendars and schedules;
- Reminders, notifications, and notices for patients via SMS;
- Requesting appointments online;
- Treatment planning: recording conditions, scheduling procedures, and managing the entire treatment plan;

- Finances: tracking payments, managing expenses, overseeing staff remunerations;
- Health Insurance integration;
- Personalized emails to patients;
- Attendance tracker for staff;
- Inventory management: tracking inventory across multiple locations, creating virtual warehouses, setting quantity reminders, and top-up depleted items;
- Business Intelligence: reporting system, charting, exporting data.

Availability:

Connection with a web browser (preferably Google Chrome) and the Internet is required. The software does not require any installations.

Cross-platform:

The software is compatible with the Windows, Mac, and Linux operating systems. The platform is accessible on mobile devices. Additionally, on iOS and Android devices, the company suggests installing the mobile companion app – Dental Go, which offers some basic functionalities optimized for smaller touch devices.

Requirements for technical knowledge:

No technical knowledge is required. There is no information on the software website whether a training course is included in the purchase.

Integration capabilities:

Complies with Health insurance companies in some countries. Integrates with ProductDent e-shop that finds needed items from participating manufacturers and manages orders. It is part of The MediCloud Ecosystem and allows integration with the company's programs:

- PatientDent (a platform for patients);
- ProductDent (bringing suppliers and practices together in the Cloud);
- AnalyticsDent (BI and reporting Tools for large businesses);
- LabsDent (dental labs' entry point into the Cloud).

Security and compliance:

The software complies with European Union regulations on Information privacy in the European Union (EU) and the European Economic Area (EEA) (GDPR).

Customer support:

No information was stated about customer support.

Testimonials:

The respondents pointed out the following disadvantages of this system in the questionnaire: poor integration with other software and tools, lack of support, and advanced data analysis.

4.2.6. PERIOSYSTEM

PerioSystem benefits from the PM' UP and JEI (Jeune Entreprise Innovante) programs.
Award winner of the First Grand Prix in Practical Innovation contest organized by Information Dentaire in collaboration with Amex.

Price:

The purchase of account opening and all the basic modules installation costs are 450€. There are monthly and annual subscriptions. Monthly: 125€ per month per practitioner or 95€ per month per practitioner from the second practitioner within the same dental clinic. Annual: 1250€ per year or 950€ per year from the second user within the same dental clinic. In-office training, data transfer from previously used software, and online or offline intervention will be worth an additional 490€. The price of the MagiCommande bracelet used for gesture recognition and remote control is 400€. Also, the company offers automated SMS appointment reminders, sent directly from PerioSystem, which cost 120€ per 1,000 SMS or 200€ per 2,000 SMS. Moreover, it is possible to purchase packs for digital mailing - price varies according to the number of purchased pages and their color (black and white or colored). In addition, the company offers Perioline (dental and periodontal charting solutions) from 29€ per month per user but with a 15-day free trial plan. For activating voice recognition, the customer will be charged another 250€.

Usability:

Almost two minutes were spent to perform the previously mentioned scenario for evaluating this criterion due to the comprehensible dashboard and overall user-friendly and intuitive interface design. There were no difficulties experienced with this process. However, it is necessary to point out that there was no possibility to set up notifications about patient appointments, as this option is available only for an additional fee, specified earlier in the Price section.

Functions:

- Built-in advanced charting and analysis of treatment evolution;
- Prescription assistance:
    - Regularly updated CCAM nomenclature, integrated Vidal database;
    - Examination recommendations based on analysis of the patient's medical check-up.
- Optimized traceability:
    - Scanning, photographing, or downloading instrument barcodes or QR codes and saving data in the patient record.
- Imaging & Media:
    - Interface with imaging software;
    - Automatic media storage is in the patient's file directly from the camera.
- Voice recognition: PerioSystem repeats words for validation and charts;
- Gesture recognition: operating the application remotely, accessing patient files, X-rays, and diaries with simple gestures while maintaining sterile conditions;
- A comprehensive selection of fact sheets and publications to help educate and motivate patients;
- Administrative automatization (letters, e-mails, prescriptions, treatment plans, and quotations);
- PerioSystem's "Sensitive Data" allows to send registered mail directly with personalized correspondence;
- Medical check-up on tablet and electronic signature:
    - Reminder alerts every six months and automatic saving in the patient's PDF file;
    - Multilingual data entry: the patient answers in his/her language, and the answers are translated into the practitioner's language;
    - Retrieval and analysis of responses: allergy and history records;

- Personalized interactive calendar.

Availability:

An Internet connection to access PerioSystem is required. No installation is needed.

Cross-platform:

The software is compatible with Windows, Linux, and Mac operating systems. Connecting via desktop, tablet, or smartphone is possible.

Requirements for technical knowledge:

The company provides customers an additional fee for 3D educational videos and in-office training.

Integration capabilities:

The software is compatible with CCAM nomenclature, Vidal database, imaging systems, Perioline (PerioSystem's charting solution), and MagiCommande bracelet for gesture recognition and remote control.

Security and compliance:

PerioSystem provides secure, high-performance data storage in data centers approved by the French Ministry of Health. PerioSystem is a LAP-certified online dental software.

Customer support:

The company's Assistance and Support department is at service by telephone or via a dedicated chat integrated into the application. Technicians can also visit the customer's clinic if required.

Testimonials:

There are two reviews on Google with an average estimation of 5 stars out of 5. ADSERVIO on the Europian Commission | Cordis | EU research results website states that "Periosystem combines the functionalities of five dental software services: practice management; patient communication; treatment planning; patient education; and accounting. It introduces four significant technological advances to clinical dentistry: (i) voice recognition, (ii) motion recognition, (ii) facial recognition, and (iv) augmented reality".

4.3. A comparative table of selected softwares

For presenting a visually clear and organized overview of the selected dental practice management software analyzed in the previous part of the study, a comparative table is described below.

Criterion / Category	Software's name / Subcategory	Gesden G5	Aquar Software	Cliniwin	EasyClinic	PracticeDent	Periosystem
Operating System Compliance	Windows	☑	☑	☑	☑	☑	☑
	Linux	☐	☐	☑	☑	☑	☑
	MacOS	☐	☑	☑	☑	☑	☑
Cross-platform	Desktop	☑	☑	☑	☑	☑	☑
	Tablet	☐	☑	☑	☑	☑	☑
	Mobile	☐	☐	☑	☑	☑	☑
Availability	Offline	☑	☑	☐	☐	☐	☐
	Online	☐	☐	☑	☑	☑	☑
Technical Training	Is it provided?	☑	☑	☑	☐	☐	☑
Customer Support	Is it provided?	☑	☑	☑	☑	☐	☑
Usability							
Patients Records	Managing patient records	☑	☑	☑	☑	☑	☑
	Periodontogram	☑	☐	☐	☐	☐	☑
	Laboratory records keeping;	☐	☑	☐	☑	☐	☐
	Issuing prescriptions	☑	☑	☐	☑	☐	☑
	Patient Portal	☐	☐	☐	☑	☐	☐
Billing & Accounting	Invoices and receipts	☑	☑	☑	☑	☑	☐
	Control of incomes & expenses	☑	☑	☑	☑	☑	☐
	Voucher management	☐	☑	☐	☐	☐	☐
	Calculating the doctors' commissions	☐	☑	☑	☐	☑	☐
	Financial reports	☑	☑	☑	☑	☑	☐
	Invoicing insurance companies	☑	☑	☐	☐	☑	☐
Appointment Scheduling	Booking appointments	☐	☑	☑	☑	☑	☑
	Automated reminders	☑	☑	☑	☑	☑	☐
	Online appointments	☐	☐	☑	☑	☑	☐
Inventory and Pharmacy management	Inventory management	☐	☑	☐	☑	☑	☐
	Integrated Pharmacy	☐	☐	☐	☑	☐	☐
Communication with Patients	via SMS	☐	☑	☑	☑	☑	☐
	via e-mails	☑	☑	☑	☑	☑	☑
	via WhatsApp	☐	☑	☑	☑	☐	☐
	Messages customization	☐	☐	☐	☑	☑	☑
Access management		☑	☑	☑	☐	☐	☐
Integrations	Software's products	☑	☐	☑	☐	☑	☑
	Microsoft Office	☑	☐	☐	☐	☐	☐
	Imaging systems	☐	☑	☑	☑	☑	☑
	Electronic Health Records (EHR)	☐	☐	☐	☑	☑	☐
Others	Transferring the data from previously used programs;	☐	☐	☑	☐	☐	☐
	Data Analytics	☑	☑	☑	☑	☑	☑
	Voice recognition	☐	☐	☐	☐	☐	☑
	Gesture recognition	☐	☐	☐	☐	☐	☐

Table 8. A comparative table of dental practice management softwares (made by the author)

The purpose of this visualization is to provide a side-by-side comparison of selected software solutions based on chosen criteria described in the Methodology part of the paper, which form the left-sided columns and rows.

At the intersection of the cells, some checkmarks indicate the presence (filled box background and a checkmark) or absence (no background and no checkmark) of the function, option, or other criterion specified in the left column. In conclusion, comparing the selected software and reviewing the pictorial evaluation table allows to assume the following.

Neither of the programs offers a versatile solution for all the tasks, offering only some of the functionalities described in the left-hand columns. To become the ultimate solution, each of the analyzed software requires enhancements and the addition of several features. However, while conducting a comparative analysis of the mentioned solutions, was observed a tendency to improve performance and integrate innovative features, specifically in the recently developed software. Although, along with creating and offering innovations, which were absent in competitors' existing products, the software developers did not comprehensively achieve the balance between incorporating new features and maintaining the software's core functionality and simplicity.

The complete absence of financial and accounting modules in the Periosystem can confirm this statement. At the same time, this software stands out in the market with other innovations, such as voice and gesture recognition, which none of the other reviewed programs offer. Also, for example, PracticeDent, Periosystem, Cliniwin, and EasyClinic, while focusing on cross-platform flexibility, compatibility with all operating systems, and accessibility, do not provide users with advanced features in terms of integrations or advanced patient records management, which are provided by competing programs.

According to the table, the most complex and functional software is EasyClinic, with 27 functions out of 38 specified. However, with such a result, it still can not be described as the most suitable or efficient. In conclusion, among the analyzed programs, no software is cross-platform, accessible, provides multiple integration options, and includes all the features needed for effective dental practice management in the categories mentioned, such as Patient Records, Billing and

Accounting, Appointment Scheduling, Inventory and Pharmacy management, Communication with Patients, Access Management and others.

Therefore, a comprehensive and profound analysis of existing software allowed to identify this type of software's shortcomings and provided a basis for improvement suggestions in the further part of the research paper.

4.4. Identifying problematic aspects of existing solutions and proposals for improvement

Based on a comprehensive comparative analysis, the feedback from dental professionals, and the obtained data from two profound interviews, several areas for improvement in existing dental management software were defined. Here are some suggestions to address these problematic aspects.

1) **Enhancing User Interface (UI) and general ease of use.**

Throughout the study, it was determined that a user-friendly interface is an essential aspect of the software, which offers efficient software manipulation, assuring stable performance and smooth operations. The proposal entails improving existing solutions by creating a more intuitive UI and reducing the number of actions required to operate to resolve the issues of poorly designed and structured interface, unpleasant aesthetic appearance, and difficulties manipulating the program. Also, due to the complexity of the user interface structure, customers often approach developers expecting explanations and clarifications on how to use the program. The flow of requests can be reduced by implementing the above suggestion.

2) **Providing more informative training and customer support.**

When contacting customer support with a problem, users are often not provided adequate assistance. Firstly, the suggestion is to improve training resources, such as user manuals, educational webinars, video tutorials, synchronized training for all personnel, in-office training, and online documentation, to help users effectively utilize the software. Besides, offering personalized onboarding and implementation support to assist clinics in the transition process would be helpful.

Secondly, providing responsive, ongoing, and multilingual customer support through multiple phone, online chat, or e-mail channels would promptly address user inquiries and issues.

3) **Improving data reporting and analytics.**

The suggestion includes enhancing reporting and analytics capabilities to provide more comprehensive and customizable reports on various metrics, such as financial performance, patient demographics, and treatment patterns. Developers should consider implementing more data export and exchange options to provide enough tools for advanced reporting and analytics.

4) **Increasing customization options.**

The proposal is to empower customers with the ability to personalize the interface, such as customizing workflows, templates, logos, and features according to their preferences and the clinic's needs.

5) **Expanding the field of possibilities for integrating other systems.**

The suggestion is to enhance integration capabilities to seamlessly integrate with other systems and technologies used in dental clinics, such as:

- Digital imaging tools to capture and analyze X-rays, intraoral scans, cone-beam computed tomography (CBCT), and 3D models;
- Digital treatment tools – intraoral cameras, CAD/CAM systems, and digital scanners;
- Microsoft Office and tools like PowerBI for data analysis;
- Electronic Health Records (EHRs);
- Patient communication tools.

Also, developing partnerships or APIs with other vendors to facilitate smooth data transfer and interoperability might be helpful.

6) **Enhancing patient engagement features and communication.**

This proposal includes integrating patient engagement features, such as education modules or patient portals, to access their patient profile online and have the ability to request appointments, update health status, etc. Also, implementing functions of automated appointment reminders and treatment plan notifications might improve communication with existing and potential patients.

7) **Providing mobile accessibility.**

The suggestion involves developing and enabling the feature of mobile access to patient records, scheduling appointments, and managing clinic operations. Operating processes from a mobile phone or tablet from any location would enhance user experience.

8) **Improving data management and security.**

Developers should intensify their oversight of personal data security measures, eliminating the possibility of data breaches and ensuring compliance with privacy regulations. The suggestion considers implementing data backup services and recovery procedures and the ability to set up accesses to define multiple levels of permissions for dental owners, dentists, or staff.

9) **Focusing on the balance between maintaining existing solutions and further introduction of innovative technologies.**

Thus, developers should prioritize providing users with essential functions that would completely satisfy the needs of professionals and clinics and only then implement innovations.

10) **Increasing the performance speed of the software.**

By addressing these areas for improvement, dental management software can provide a more seamless and efficient experience for dental professionals, improve clinic operations, and enhance patient care.

5. CONCLUSIONS, LIMITATIONS, AND FUTURE AREAS FOR RESEARCH

5.1. Conclusions

In conclusion, the rapid development of modern technologies raises the problem of choosing and implementing effective software for dental clinics. By implementing dental practice management software, managing practice, ensuring work efficiency, improving the quality of medical services, avoiding errors, and losing time and resources can be done. However, current solutions may only be suitable for some dental practitioners and may not meet the specific clinic needs.

In the course of the study, all the set objectives were achieved. The research was based on a comprehensive literature review and a comprehensive comparative analysis, including software analysis, specifically, evaluating the functionality, features, and usability of available dental practice management software systems and describing their cons and pros, addressing various demands of a dental practice. The study aimed to identify gaps, shortcomings, and limitations in the existing software that obstruct effective dental practice management with the following variables: Price, Usability, Functions, Availability, Requirements for technical knowledge, Integration capabilities, Security and compliance, and Customer support.

Also, an essential aspect of the topic was obtaining feedback from existing software users. The paper was focused on researching the customer experience of dental professionals and the software's impact on workflow processes to explore potential opportunities for improvement, which, as a result, can contribute to enhancing the activities of dental practices and increasing the quality of providing services to patients.

Therefore, evidence-based practical recommendations for optimizing software solutions to meet the evolving needs of dental practices were developed. The suggestions addressed the following aspects of the dental practice management software:

1. Enhancing User Interface (UI) and general ease of use;
2. Providing more informative training and customer support;
3. Improving data reporting and analytics;
4. Increasing customization options;

5. Expanding the field of possibilities for integrating other systems;
6. Enhancing patient engagement features and communication;
7. Providing mobile accessibility;
8. Improving data management and security;
9. Focusing on the balance between maintaining existing solutions and further introduction of innovative technologies;
10. Increasing the performance speed of the software.

5.2. Limitations

Several limitations must be considered when analyzing and evaluating existing dental practice management software. The evaluation was primarily based on surveys and interviews with dental professionals working in Spain. The sample size used in this study was limited. Due to resource constraints, including many dental practices in the analysis was not possible. As a result, the findings may only represent a part of the dental practice population. Also, the research was based on analyzing six software solutions mainly used by the respondents. While this provided valuable insights into the software's functionality and effectiveness, it may capture only some existing solutions. Thus, the study's results could have been supported by analyzing a more significant number of programs and respondents quantity, which broadened the comparison field.

Furthermore, the study focused on identifying gaps and opportunities for improvement in existing dental practice management software. As a result, the analysis needed to be more balanced toward identifying shortcomings rather than highlighting the software's strengths. Future research could consider a more balanced approach to evaluate the overall performance of the software.

Additionally, the limitation of this study is the need for more previous studies. Dental practice management software is a relatively new research area with limited literature. Establishing a comprehensive theoretical framework and comparing the findings with existing studies was challenging.

5.3. Potential areas for future research

Future research in this area should consider building on the findings of this study to contribute to the growing body of knowledge.

Additionally, access to data from dental practices was a limitation in this study. Some practices were reluctant to share sensitive information or were unavailable for participation. This limited the amount of data that could be analyzed and may have influenced the overall findings. Future research could consider strategies to overcome these restrictions, such as offering incentives or ensuring confidentiality.

Lastly, this research paper focused on evaluating existing dental practice management software and should have considered the development of new software solutions. Future research could explore developing and implementing innovative software solutions to address the identified gaps and opportunities. Alternatively, future researchers could collaborate directly with an existing company, its founders, and developers to investigate the software's strengths and weaknesses, identify ways to improve it, and directly implement innovative features or upgrade existing ones.

Overall, while this research provides valuable insights into the gaps and opportunities for improvement in existing dental practice management software, it is essential to acknowledge and consider the methodological and researcher limitations outlined above. These constraints provide opportunities for future research to advance further the understanding of dental practice management software and its impact on dental practices. By addressing these potential areas for future research, the dental industry can continue to improve and optimize the use of practice management software, ultimately leading to better patient care, increased practice efficiency, and improved overall dental practice management.

6. BIBLIOGRAPHY

1. Ismail, N. I., & Abdullah, N. H. (2016). Hospital Information System (HIS) implementation in Malaysian Public Hospitals. *International Journal on Information 19(7B),* 2833-2838.
2. Dasanayake, D., Gunasekara, P., Wickramasinghe, H., Fernando, S., & Kulasekera, A. L. (2018). Automated Hospital Ward Management System Interacting with Mobile Robot Platform WDBOT. *2018 IEEE International Conference on Mechatronics and Automation (ICMA)*. https://doi.org/10.1109/icma.2018.8484356
3. Shamsoddin, E., DeTora, L., Tovani-Palone, M. R., & Bierer, B. E. (2021). Dental Care in Times of the COVID-19 Pandemic: A review. Medical Sciences, 9(1), 13. https://doi.org/10.3390/medsci9010013
4. Carvalho, J. V., Rocha, Á., De Vasconcelos, J. B., & Abreu, A. (2019). A health data analytics maturity model for hospitals information systems. *International Journal of Information Management*, *46*, 278–285. https://doi.org/10.1016/j.ijinfomgt.2018.07.001
5. Tooranloo, H. S., & Saghafi, S. (2020). Assessing the risk of hospital information system implementation using IVIF FMEA approach. *International Journal of Healthcare Management*, *14*(3), 676–689. https://doi.org/10.1080/20479700.2019.1688504
6. Demirel, D. (2018). Hospital management information systems in health sector and development in Turkey. *ResearchGate*. https://www.researchgate.net/publication/329450531_Hospital_Management_Information_Systems_in_Health_Sector_and_Development_in_Turkey
7. Jayatissa, P. (2023, June 29). A review of dental informatics : current trends and future directions. *arXiv.org.* https://arxiv.org/abs/2307.03686
8. Acharya, A., Schroeder, D., Schwei, K. M., & Chyou, P. (2017). Update on Electronic Dental Record and Clinical Computing adoption among dental practices in the United States. *Clinical Medicine & Research*, 15(3–4), 59–74. https://doi.org/10.3121/cmr.2017.1380
9. Estai, M., Kruger, E., Tennant, M., Bunt, S., & Kanagasingam, Y. (2016). Challenges in the uptake of telemedicine in dentistry. *Rural and Remote Health*, 16(4), 1–5. https://search.informit.org/doi/abs/10.3316/INFORMIT.206881898506247
10. Mihailovic, B., Miladinovic, M., & Vujicic, B. (2011). Telemedicine in Dentistry (Teledentestry). *In Advances in Telemedicine: Applications in Various Medical Disciplines and Geographical Regions* (pp. 215–231).

https://books.google.es/books?hl=ru&lr=&id=MdCcDwAAQBAJ&oi=fnd&pg=PA215&dq=telemedicine+in+dentistry&ots=XVL6KTooTI&sig=hburLCotK344sJOlgnVZHsqrjuU&redir_esc=y#v=onepage&q=telemedicine%20in%20dentistry&f=false

11. Schwendicke, F., Samek, W., & Krois, J. (2020). Artificial intelligence in dentistry: chances and challenges. *Journal of Dental Research*, 99(7), 769–774. https://doi.org/10.1177/0022034520915714
12. Clough, F., & Patel, N. (2018). Digital Transformation in Dentistry: an organisational view. *Primary Dental Journal*, 7(2), 28–29. https://doi.org/10.1177/205016841800700204
13. Naamati-Schneider, L., & Salvatore, F. P. (2022). Digital transformation in private dental clinics. *In Springer eBooks* (pp. 201–218). https://doi.org/10.1007/978-3-031-07769-2_10
14. Farman, A. G., & Farman, T. T. (2004). A status report on digital imaging for dentistry. *Oral Radiology*, 20(1). https://doi.org/10.1007/s11282-004-0003-2
15. Cederberg, R. A., Walji, M. F., & Valenza, J. A. (2014). Electronic health records in dentistry: clinical challenges and ethical issues. *In Computers in health care* (pp. 1–12). https://doi.org/10.1007/978-3-319-08973-7_1
16. Vandenberghe, B., Jacobs, R., & Bosmans, H. (2010). Modern dental imaging: a review of the current technology and clinical applications in dental practice. *European Radiology,* 20(11), 2637–2655. https://doi.org/10.1007/s00330-010-1836-1
17. Dhanore, P., Shaik, & Ramtekkar, P. (2016). Dental Clinic Management System - A New Approach. *IJCSET*, *6*(5), 176–178.
18. Teke A., Londh S., Oswal P., & Malwade P. S. S. (2019). Online Clinic Management System. *International Journal of Advance Scientific Research and Engineering Trends*, 4(2), 2–5.
19. Sidek, Y. H., & Martins, J. T. (2017). Perceived critical success factors of electronic health record system implementation in a dental clinic context: An organisational management perspective. *International Journal of Medical Informatics*, *107*, 88–100. https://doi.org/10.1016/j.ijmedinf.2017.08.007
20. Symey, Y., Sankaranarayanan, S., & Binti Sait, S. N. (2013). Application of Smart Technologies for Mobile Patient Appointment System - PDF Free download. *International Journal of Advanced Trends in Computer Science and Engineering*, *2*(4), 74–85. https://docplayer.net/15155594-Application-of-smart-technologies-for-mobile-patient-appointment-system.html

21. Berg, M. (2001). Implementing information systems in health care organizations: myths and challenges. *International Journal of Medical Informatics*, *64*(2–3), 143–156. https://doi.org/10.1016/s1386-5056(01)00200-3

22. Haux, R. (2006). Health information systems – past, present, future. *International Journal of Medical Informatics*, *75*(3–4), 268–281. https://doi.org/10.1016/j.ijmedinf.2005.08.002

23. Droma, F., Bulyaba, H., Ssebwato, J., Nakawooya, K., Musah, K.C., Ongoro, D.A., Suuna, C., & Ndege, R.M. (2009). An automated system for patient record management: a case study of St. Francis Hospital Nsambya. *Semantic Scholar*. https://www.semanticscholar.org/paper/An-automated-system-for-patient-record-management%3A-Droma-Bulyaba/d2dc87f36b3056ba8d75e33715b19796f6d7e2bd

24. Krobock J. R. (1984). A taxonomy: hospital information systems evaluation methodologies. *Journal of medical systems*, *8*(5), 419–429. https://doi.org/10.1007/BF02285254

25. Meier, C. A., Fitzgerald, M. C., & Smith, J. M. (2013). eHealth: extending, enhancing, and evolving health care. *Annual review of biomedical engineering*, *15*, 359–382. https://doi.org/10.1146/annurev-bioeng-071812-152350

26. Musa, A., Yusuf, Y., & Meckel, M. (2012). A hospital resource and patient management system based on real-time data capture and intelligent decision making. *ResearchGate*, 776–779. https://doi.org/10.1109/icsai.2012.6223125

27. Srivastava, K., Choubey, D. K., & Kumar, J. (n.d.). Implementation of inventory management system. In *Social Science Research Network*. International Conference on Innovative Computing and Communication (ICICC-2020), Patna, India. https://doi.org/10.2139/ssrn.3563375

28. Balaraman, P., & Kosalram, K. (2013). E–Hospital Management & Hospital Information Systems – Changing Trends. *International Journal of Information Engineering and Electronic Business*, *5*(1), 50–58. https://doi.org/10.5815/ijieeb.2013.01.06

29. Hu, D., Xu, W., Shen, H., & Li, M. (2005). Study on information system of health care services management in hospital. *ResearchGate*. International Conference on Services Systems and Services Management : proceedings of ICSSSM'05, Chongqing, China. https://doi.org/10.1109/icsssm.2005.1500249

30. Donetto, S. (2014). *Using Experience-based Co-design (EBCD) to improve the quality of healthcare: mapping where we are now and establishing future directions*.

https://www.semanticscholar.org/paper/Using-Experience-based-Co-design-(EBCD)-to-improve-Donetto-Tsianakas/259c2ebc8e3e39c42c4a1ac50df8ccd2f1e04994

31. Balas, E. A., Jaffrey, F., Kuperman, G. J., Boren, S. A., Brown, G. D., Pinciroli, F., & Mitchell, J. A. (1997). Electronic communication with patients. *JAMA*, *278*(2), 152. https://doi.org/10.1001/jama.1997.03550020084043
32. Hofmans-Okkes, I., & Lamberts, H. (1996). The International Classification of Primary Care (ICPC): new applications in research and computer-based patient records in family practice. *Family Practice*, *13*(3), 294–302. https://doi.org/10.1093/fampra/13.3.294
33. Nifakos, S., Chandramouli, K., Nikolaou, C. K., Papachristou, P., Koch, S., Panaousis, E., & Bonacina, S. (2021). Influence of Human Factors on Cyber Security within Healthcare Organisations: A Systematic Review. *Sensors*, *21*(15), 5119. https://doi.org/10.3390/s21155119
34. Willing, M., Dresen, C., Haverkamp, U., & Schinzel, S. (2020). Analyzing medical device connectivity and its effect on cyber security in german hospitals. *BMC Medical Informatics and Decision Making*, *20*(1). https://doi.org/10.1186/s12911-020-01259-y
35. Tariq, S., Gupta, N., Gupta, P., & Sharma, A. (2021). Artificial intelligence in public health dentistry. *International Healthcare Research Journal*, *5*(9), RV1–RV5. https://doi.org/10.26440/ihrj/0509.12489
36. Tandon, D., Rajawat, J., & Banerjee, M. (2020). Present and future of artificial intelligence in dentistry. *Journal of Oral Biology and Craniofacial Research*, *10*(4), 391–396. https://doi.org/10.1016/j.jobcr.2020.07.015
37. Vermeeren, A., Law, E. L., Roto, V., Obrist, M., Hoonhout, J., & Väänänen-Vainio-Mattila, K. (2010). User experience evaluation methods. *Proceedings of the 6th Nordic Conference on Human-Computer Interaction 2010, Reykjavik, Iceland, October 16-20, 2010*. https://doi.org/10.1145/1868914.1868973
38. *Dental market size worldwide 2021 | Statista*. (2019, August 9). Statista. https://www.statista.com/statistics/731751/global-dental-market-size/
39. Best Dental Practice Management Software | *G2*. (2023) https://www.g2.com/categories/dental-practice-management
40. TheExpressWire. (2023, July 25). Dental Market Insights | 2023-2030. *Digital Journal*. https://www.digitaljournal.com/pr/news/theexpresswire/dental-market-insights-2023-2030

41. *How is information technology used in accounting?* (2019, February 12). Small Business - Chron.com. https://smallbusiness.chron.com/information-technology-used-accounting-2101.html

42. Ghasemi, M., Shafeiepour, V., Aslani, M., & Barvayeh, E. (2011). The impact of Information Technology (IT) on modern accounting systems. *Procedia - Social and Behavioral Sciences*, *28*, 112–116. https://doi.org/10.1016/j.sbspro.2011.11.023

43. Burke L., Weill B. (2018). Information Technology for the Health Professions (5th Edition). *Pearson*, 452 p.

44. [68] Mattheos, N., Stefanovic, N., Apse, P., Attstrom, R., Buchanan, J., Brown, P., Camilleri, A., Care, R., Fabrikant, E., Gundersen, S., Honkala, S., Johnson, L., Jonas, I., Kavadella, A., Moreira, J., Peroz, I., Perryer, D. G., Seemann, R., Tansy, M., Thomas, H. F., … Walmsley, A. D. (2008). Potential of information technology in dental education. *European journal of dental education : official journal of the Association for Dental Education in Europe*, *12 Suppl 1*, 85–92. https://doi.org/10.1111/j.1600-0579.2007.00483.x

45. Runeson, P., Höst, M., Rainer, A., & Regnell, B. (2012). *Case study research in software engineering*. https://doi.org/10.1002/9781118181034

46. Hollweck, T. (2015). Robert K. Yin. (2014). *Case Study Research Design and Methods (5th ed.). The Canadian Journal of Program Evaluation*, *30*(1), 108–110. https://doi.org/10.3138/cjpe.30.1.108

47. Verner, J. M., Sampson, J., Tosic, V., Bakar, N. a. A., & Kitchenham, B. (2009). Guidelines for industrially-based multiple case studies in software engineering. *RCIS 2009*. The Third International Conference on Research Challenges in Information Science (RCIS), Morocco. https://doi.org/10.1109/rcis.2009.5089295

48. Jöhnk, J., Röglinger, M., Thimmel, M., & Urbach, N. (2017). How to Implement Agile IT setups: a Taxonomy of Design options. *European Conference on Information Systems*.

49. Gopal, G. V., Suter-Crazzolara, C., Toldo, L., & Eberhardt, W. (2018). Digital transformation in healthcare – architectures of present and future information technologies. Clinical Chemistry and Laboratory Medicine, 57(3), 328–335. https://doi.org/10.1515/cclm-2018-0658

50. Dedrick, J., Gurbaxani, V., & Kraemer, K. L. (2003). Information technology and economic performance. ACM Computing Surveys, 35(1), 1–28. https://doi.org/10.1145/641865.641866

51. Luftman, J. N., Lewis, P., & Oldach, S. H. (1993). Transforming the enterprise: The alignment of business and information technology strategies. Ibm Systems Journal, 32(1), 198–221. https://doi.org/10.1147/sj.321.0198
52. Kasim, T., Haracic, M., & Haracic, M. (2018). The improvement of business efficiency through business process management. Economic Review: Journal of Economics and Business, 16(1), 31–43. https://www.econstor.eu/handle/10419/193881
53. Rubens, P., & Olavsrud, T. (2022). What is business process management? The key to enterprise agility. *CIO*. https://www.cio.com/article/230560/what-is-business-process-management-bpm-the-key-to-enterprise-agility.html
54. Gopal, G. V., Suter-Crazzolara, C., Toldo, L., & Eberhardt, W. (2018). Digital transformation in healthcare – architectures of present and future information technologies. Clinical Chemistry and Laboratory Medicine, 57(3), 328–335. https://doi.org/10.1515/cclm-2018-0658
55. Gardner B. (2011). Responsive Web-design: Enriching the User Experience. Sigma Journal: Inside the Digital Ecosystem, 11(1), 13-19.
56. Seymour, T., Frantsvog, D., & Graeber, T. (2012). Electronic Health Records (EHR). *American Journal of Health Sciences (AJHS)*, 3(3), 201–210. https://doi.org/10.19030/ajhs.v3i3.7139
57. Health informatics. (2010). Security requirements for archiving of electronic health records — Principles. (ISO Standard No. 21547:2010). https://www.iso.org/obp/ui#iso:std:iso:ts:21547:ed-1:v1:en
58. Health informatics. (2019). Electronic health record communication — Part 1: Reference model. (ISO Standard No. 13606-1:2019).
59. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). https://eur-lex.europa.eu/eli/reg/2016/679/oj
60. Zulyanti, N. R., & Irawan, M. R. N. (2023). Customer Relationship Management: Literature review. International Journal of Science, Technology & Management, 4(4), 884–892. https://doi.org/10.46729/ijstm.v4i4.881
61. Basholli, F., Mezini, R., & Basholli, A. (2023). Security in the components of information systems. Advanced Engineering Days, 7, 185-187.

62. Wahdiniawati, S. A., Rukmana, A. Y., Fajrillah, Ma'sum, H., Hasniaty, Pasaribu, J. S., Fauzan, R., Soetikno, Y. J. W., Aditya, A., & Harto, B. (2023). ENTERPRISE INFORMATION SYSTEM. *Get Press Indonesia.*

63. Grace, M. F., Leverty, J. T., Phillips, R. D., & Shimpi, P. (2014). The Value of Investing in Enterprise Risk Management. Journal of Risk and Insurance, 82(2), 289–316. https://doi.org/10.1111/jori.12022

64. Agustina, L., & Baroroh, N. (2016). The relationship between enterprise risk management and firm value mediated through the financial performance. Review of Integratif Business and Economic Research, 5 (1) pp. 128- 138.

ANEXO I. RELACIÓN DEL TRABAJO CON LOS OBJETIVOS DE DESARROLLO SOSTENIBLE DE LA AGENDA 2030

Anexo al Trabajo de Fin de Grado y Trabajo de Fin de Máster: Relación del trabajo con los Objetivos de Desarrollo Sostenible de la agenda 2030.

Grado de relación del trabajo con los Objetivos de Desarrollo Sostenible (ODS).

Objetivos de Desarrollo Sostenibles	Alto	Medio	Bajo	No Procede
ODS 1. **Fin de la pobreza.**				X
ODS 2. **Hambre cero.**				X
ODS 3. **Salud y bienestar.**	X			
ODS 4. **Educación de calidad.**				X
ODS 5. **Igualdad de género.**				X
ODS 6. **Agua limpia y saneamiento.**				X
ODS 7. **Energía asequible y no contaminante.**				X
ODS 8. **Trabajo decente y crecimiento económico.**		X		
ODS 9. **Industria, innovación e infraestructuras.**			X	
ODS 10. **Reducción de las desigualdades.**				X
ODS 11. **Ciudades y comunidades sostenibles.**				X
ODS 12. **Producción y consumo responsables.**				X
ODS 13. **Acción por el clima.**				X
ODS 14. **Vida submarina.**				X
ODS 15. **Vida de ecosistemas terrestres.**				X
ODS 16. **Paz, justicia e instituciones sólidas.**				X
ODS 17. **Alianzas para lograr objetivos.**				X

Table 9. Description of the alignment of the TFM with the SDGs by the level of the interconnectivity.

SDG 3: Salud y bienestar (Good health and well-being) — highly applicable.

This study can contribute to SDG 3 in the following ways:

- Efficient dental practice management software can enhance the effectiveness and quality of dental care services as well as help dental professionals provide better patient care, preventive care, early intervention, and reduce health risks ;
- This type of software can increase the accessibility to qualified essential dental services, thereby contributing to improved oral health and overall well-being;
- Therefore, efficient dental practices can lead to reduced operational costs, which can be beneficial for both dental practitioners and patients, potentially lowering the cost of dental services.

SDG 8: Trabajo decente y crecimiento económico (Decent work and economic growth) — moderately applicable.

This research can help achieve SDG 8 in the following ways:

- Streamlining tasks with the admission of dental practice management software potentially increases dental professionals' satisfaction with the workflow and the job overall and levels up productivity through technological upgrading and innovation;
- Developing and improving dental practice management software can stimulate economic growth by creating job opportunities in software development, customer support, and training for dental professionals.

SDG 9: Industria, innovación e infraestructuras (Industry, innovation and infrastructure) — lowly applicable.

The TFM may apply to SDG 9 in the following way:

- Identifying areas for software improvement can drive innovation in the dental industry. New features and functionalities can contribute to the growth of the dental technology sector.