Ciência & Saúde Coletiva
cienciaesaudecoletiva.com.br
ISSN 1413-8123. v.31, n.5
DOI: 10.1590/1413-81232026315.24242025EN

Electronic system for clinical information management for dental schools: digital integration of teaching and service

Pedro Afonso Machado Nunes https://orcid.org/0009-0007-9399-0013 [1]; Francisco Wilker Mustafa Gomes Muniz https://orcid.org/0000-0002-3945-1752 [1]; Kaue Collares https://orcid.org/0000-0002-7276-1074 [1]; Otávio Pereira D'Avila https://orcid.org/0000-0003-1852-7858 [1]; Mateus Bertolini Fernandes dos Santos https://orcid.org/0000-0001-5477-4077 [1]

Abstract *The present study aimed to develop and implement an electronic information management system at a dental school of a public university in Brazil. Workflow mapping was carried out using the business process model and notation (BPMN) methodology and the Miro platform. The macroprocess was patient-centered, covering the journey from clinic admission to discharge. Subprocesses were detailed by user type and validated with involved professionals. The system was initially tested with fictitious data and, after adjustments, applied in specific courses. User perception was assessed via questionnaire. The mapping enabled a detailed organizational chart, identifying bottlenecks and improvement opportunities. Users received specific access levels; implementation involved data migration, academic system integration, and features to prevent pending tasks. The system's self-assessment collected 150 responses: 76% agreed on its usefulness, while 94% highlighted the need for ongoing training. Despite challenges, the system promoted significant progress in process digitization, faster communication, and traceability of clinical activities, with potential for waiting list control and academic tracking of students.*

Key words *Digital health, Electronic health records, Medical records, Hospital, University*

[1] Universidade Federal de Pelotas. Rua Gonçalves chaves 457, sala 508, Centro. 96.015-560 Pelotas RS Brasil. mateusbertolini@yahoo.com.br

Introduction

The computerization of medical records and administrative workflows is a reality in all areas of knowledge, leading to the optimization of bureaucratic tasks and improvements in the effectiveness and efficiency of services. In the healthcare field, especially in public services, the computerization of patient records brings several benefits to users, be they patients, members of the administration, or healthcare professionals[1]. From an organizational point of view, information stored in printed format can only be accessed physically, in addition to being subject to loss, data duplication, and difficulty in organizing or grouping individual or collective data, such as managing waiting lists, controlling processes, and accounting for procedures and operational costs, as well as the growing demand for physical space and staff to store these documents[2].

The disorganization of the information flow and the work process is perceived negatively by both healthcare professionals and users of the Unified Health System (SUS) with regard to speed and access to the service[3]. In this sense, the computerization of medical records and complementary exams ensures greater accessibility and efficiency, since the information is centralized in a database and can be accessed by different professionals simultaneously, facilitating communication and multidisciplinary care, with no need for document duplication or reworking. Information gathering, four scenarios that take place daily within a Dental School. Furthermore, computerization reduces the possibility of errors related to manual records, such as typing errors or loss of information, as well as prevents the duplication of records, thereby ensuring data integrity and consistency.

From an administrative standpoint, computerization ensures better organization and control of flows and processes, such as managing inventory materials, controlling the entry and exit of materials in the sterilization sector, scheduling and referring patients, among others. Furthermore, reports on various aspects can be created, ranging from the use of consumable materials for a given discipline to obtaining the entire history of care provided[6,7]. From a legal standpoint, computerization also provides legal security to administrators/directors of institutions, as it reduces the risk of misplacement or loss of patient information or examinations[8].

With regard to education, computerization allows students in the health field to move even closer to the professional reality and, with faster access and without the risk of loss, allows for better training of the students by providing complete and up-to-date information on patients' medical/dental history, allowing for easy identification of possible drug allergies, access to previous radiographs, and a comprehensive view of the patient, which in turn enables a patient's humanization process and clinical decision-making by the future professional[7,8].

There is currently a range of options for electronic medical record systems and management of dental offices and clinics. However, the academic environment of Dental Schools presents peculiarities that are not met by the commercially available options in the Brazilian market. In this sense, our study aims to present the development and implementation of an electronic information management system, which addresses the following proposed pillars: 1) avoiding data loss or duplication; 2) control of waiting lists and improvement in case resolution, including reporting of services rendered; 3) centralization and control of procedures developed by students in different disciplines and specialties with its own evaluation tool; 4) control of processes and flows; 5) reduction of bureaucracy in the daily lives of users, with automated completion of SUS forms and the possibility of creating consolidated monthly or semesterly reports; and 6) improving communication between the educational institution and patients, aiming to reduce absenteeism in clinical activities.

Methodology

This article is a study of the development of a technological product (an electronic clinical management system for dental schools) that fulfilled the requirements for formulation, testing, implementation, and usability evaluation in the teaching-service interaction.

Flow mapping

Initially, a mapping of the flows and services developed within the Dental School at the Federal University of Pelotas (*Faculdade de Odontologia da Universidade Federal de Pelotas* – FO-UFPel), a Brazilian public university located in southern Brazil, was carried out. For this, the Business Process Model and Notation (BPMN) methodology, widely recognized for its effectiveness in representing business processes,

was used in conjunction with the Miro digital platform, in its free version. This tool was chosen, as it allows for the creation of flowcharts and mind maps in a simple, fast, and collaborative manner, meeting the project's needs.

Macroprocess mapping

Seeking to improve the resolution of dental cases, the flow mapping was planned considering the patient as the core element of the macroprocess. Thus, the macroprocess was defined as the set of integrated steps that develop from start to finish, considered from the patient's entry into the institution for the first time to the completion of dental treatment, with the possibility of a referral due to a new demand and a consequent restart of the macroprocess for the individual. The patient-centered approach was carried out with the aim of identifying bottlenecks and opportunities to achieve improvements throughout the care and service delivery chain, considering both the perspective of clinical care and the administrative processes involved.

In addition, the types of users needed for the system were also mapped, considering that each type of user can have access to different functionalities according to their needs. This mapping was carried out considering that a large part of the dental care provided at the institution is focused on the perspective of SUS.

Mapping of subprocesses (functionalities)

The system's functionalities were mapped through the subprocesses identified in the macroprocess. These subprocesses were initially divided by user type, and a study similar to that of the macroprocesses was then conducted to identify the flows of each subprocess, as well as the variables relevant to each functionality.

Each subprocess was represented in detailed flowcharts, using BPMN, which allowed for a clear view of the connections between the different stages and identified critical areas that required greater attention.

Validation of flows

The mapped workflows underwent a validation process through weekly meetings, the purpose of which was to review, discuss, and, when necessary, modify the macroprocessnand its subprocesses. These meetings were held by faculty and administrative staff involved in the various mapped processes.

Development process

The development process was conducted in a structured manner and divided into different stages, including planning, prototyping, development, testing, and deployment. Initially, all work was carried out in a local environment, using XAMPP software to manage the web server, the database server, and related services in order to ensure an isolated and controlled development environment[11]. During this phase, fictitious databases were used to represent real-world scenarios without compromising sensitive information.

The initial planning stage consisted of defining the system's objectives and requirements, aligned with the needs identified in the mapping of the macroprocess and subprocesses. Based on this, prototypes were created that visually represented the system's interface and functionalities.

During the development phase, frequent testing was carried out by the developers themselves, with the aim of identifying and correcting any errors or inconsistencies in the application code. In parallel, periodic meetings were held with the members of the group that participated in the discussion of the processes. In these meetings, participants tested the system, analyzed the implemented functionalities, and suggested improvements or adjustments needed to make the system more efficient and aligned with the demands of FO-UFPel.

Community testing with fictitious data

After initial development and validation in a local environment, the system was installed on a remote server, enabling access via the internet. On February 22, 2024, the system was officially presented to the academic community of FO-UFPel at an event dedicated to demonstrating its functionalities and objectives. Simultaneously, the testing phase began with the FO-UFPel community, using fictitious data for both users and patients in order to identify any errors, evaluate the system's performance under real-world conditions, and familiarize users with the application's concepts and workflows.

Initial implementation and on-site testing

With the start of the 2024/1 academic semester, the undergraduate course "Dental Prosthetics Unit III" and the extension project "Implantology for Dentistry Students" were selected to carry out onsite testing of the system. To enable

the use of the system, all students and teachers involved were invited to fill out a form with their personal data, which was used to create users in the system. Additionally, all employees working in the Triage sector were also registered in the system, ensuring the processing of referrals, the registration of new patients and the correct linking between patients and students, as established in the flow study.

The onsite testing was conducted on a specific domain[12], hosted by the provider Hostinger. For feedback collection, two tools were made available: a form integrated into the system itself, to record errors and send criticisms or suggestions, and the Hotjar platform, which enabled screen capture and the sending of comments directly linked to the page or functionality where difficulties or inconsistencies were observed. The errors and suggestions were forwarded to the developers for analysis and evaluation. This stage involved identifying the need for adjustments to the application code, reviewing existing functionalities and, eventually, creating new functionalities aimed at improving the usability of the system and controlling the activities performed.

Full implementation

The system implementation was conducted in a planned and structured manner, following approval by the Departmental Council (the highest instance of the Dental School, where administrative processes are handled) of FO-UFPel, with the aim of ensuring the effective integration of the developed functionalities and their adoption by the academic community. To this end, training sessions in the form of workshops were planned for all users involved, encompassing both students and different segments of the institution's staff.

Evaluation of user perception

An electronic form was made available via Google Forms to collect user opinions and perceptions about the system in general and specific functionalities. The questions also addressed participants' perceptions regarding the potential impact on the routines of FO-UFPel. In addition, open-ended questions were developed to investigate perceptions about the strengths, weaknesses, opportunities, and threats related to the electronic system. Subsequently, the responses were grouped and analyzed by thematic categories, from which a SWOT matrix was constructed to systematize the internal (strengths and weaknesses) and external (opportunities and threats) factors pointed out by the participants[13].

The collection of opinions was carried out anonymously, ensuring that respondents could freely express their criticisms, suggestions, and comments about the experience of using the tool. In addition to the qualitative data collection, an analysis of data and reports generated by the system during the implementation period was carried out. These reports included information on the activities carried out, such as the number of patients registered and treated, the number of referrals made, and the size of the waiting list; the use of specific functionalities by users; and the volume of outpatient procedure reports (*Boletins de Procedimentos Ambulatoriais* – BPAs) recorded (individual care records for each dental procedure, according to the codes of the SUS Outpatient Production System).

Results

Flow mapping

The mapping of workflows was successfully carried out using the BPMN methodology and the Miro digital platform. The use of these tools allowed for the creation of a detailed organizational chart, facilitating the visualization and organization of information. As a result, it was possible to obtain a comprehensive and clear representation of the existing processes in the institution, from the initial patient care to the completion of dental treatments, including administrative workflows indirectly related to the care provided. Consequently, a complete flowchart was created representing the entire mapping process, including the macroprocess and its subprocesses.

Macroprocess mapping

The macroprocess was defined as the set of integrated steps that encompass the complete patient care cycle, from the first contact with FO-UFPel to the completion of dental treatment, with the possibility of restarting in case of new demands. The patient-centered approach revealed important bottlenecks and opportunities for improvement, mainly related to improving communication between administrative and clinical sectors, as well as optimizing the workforce and allocating human and material resources.

During the mapping, different main types of users involved in the system were identified, namely: students, triage, technical managers (teachers and preceptors), nursing staff, sterilization, reception, clinic storeroom, main storage room, and administrator (director and course board). Each type of user was associated with different functionalities and access levels, ensuring that the specific needs of each group were met.

Mapping of subprocesses (functionalities)

The subprocesses were mapped in detail according to the identified need, considering the different levels of access and the specificities of each functionality. These subprocesses include such activities as patient scheduling, appointment registration, consultation scheduling, clinical procedure registration, certificate issuance, inventory control of dental materials, and generation of academic and administrative reports, among others.

Each subprocess was represented in detailed flowcharts using BPMN, which allowed for a clear view of the connections between the different stages. During development, critical areas requiring greater attention were identified, such as the lack of standardization in some administrative procedures and the overlapping of responsibilities between different user groups. In addition, relevant variables for each functionality were identified, including patient demographics, clinical history, and specific electronic medical records for certain specialties.

Validation of flows

The mapped workflows underwent a validation process through weekly meetings. The initial meeting included the project's main investigator, the Director, and the Vice-Director of the FO-UFPel. In subsequent meetings, the group was always expanded to include two new participants, such as faculty members, administrative and technical staff, and students. This composition strategy allowed each meeting to bring together both members previously familiar with the workflows and people who had no prior knowledge of them. The strategy of including new participants in each round allowed the workflows to be analyzed from different perspectives, ensuring that they met both administrative and academic needs. At the end of the validation process, it was found that significant changes were made to the process flowchart, resulting in the inclusion of new functionalities to improve the clarity of the steps and optimize the variables included in each of the subprocesses, making the system more aligned with the institution's real demands.

Development process

The system's development followed a modular approach, allowing new functionalities to be easily incorporated as the institution's needs evolve. This flexible architecture ensured that the system efficiently met current demands, but it also allows for the expansion and development of new tools according to future demands, or even an expansion or adaptation for other health-related courses, other institutions, or different public health contexts.

From the point of view of system architecture, technologies widely used in web development were employed to ensure accessibility, efficiency, and scalability, such as HTML5 (Hypertext Markup Language)[14] and CSS3 (Cascading Style Sheets)[15] to structure and style the graphic interface, focusing on usability and responsiveness for different devices. JavaScript[16] was used to implement dynamic interactions and asynchronous requests to the back-end, aiming to optimize user experience. In the back-end, the PHP (Hypertext Preprocessor) language was chosen to create a robust API (Application Programming Interface) that manages communication between the front-end and the database, processing requests and operations for reading, writing, updating, and deleting data, with responses structured in JSON (JavaScript Object Notation) format. For data storage, a relational SQL (Structured Query Language) database was adopted, with planned modeling to ensure integrity, consistency, and performance, in addition to the creation of indexes to optimize frequent queries and ensure the scalability of the system.

Community testing with fictitious data

To assist in the testing phase with fictitious data, channels were created on the social media platforms Instagram and YouTube with self-explanatory videos of the system's functionalities (https://www.youtube.com/@OxigenioUFPel). This simulation environment was essential for users to understand the system's workflow, identify potential difficulties, and clarify doubts before using it in a real-world context. However, despite constant outreach, participation in this testing phase was low.

Initial implementation and onsite testing

During the initial phase of system implementation, the personal data of patients who were already receiving care at FO-UFPEL, and which were stored in a repository in the Triage sector, were migrated to the system's database. The import covered 20,544 existing entries. However, 5,416 entries with duplicate individual taxpayer identification number (CPF) registrations were identified, resulting in a total of 15,128 patients registered in the system.

Next, the Triage sector's waiting list control, which until then had been done using Microsoft Excel spreadsheets, was imported into the system. This import allowed for the unification of 6,321 referrals to different specialties. However, several duplicate entries for the same CPF in the same specialty were also identified. These duplicate referrals were forwarded to the triage sector for manual verification.

Finally, a data synchronization feature was created with the UFPel academic system in order to automatically register new users, subjects offered per academic period, and the list of students enrolled in the different subjects of the Dentistry course.

A total of 89 occurrences were received, in addition to several suggestions to adjust functionalities or the need to create new functionalities due to the specificity of different academic/administrative activities. These occurrences were then reviewed by the developers and contributed to the revision of the macroprocess and to the development of specific functionalities for the inclusion of a free and informed consent form (FICF) that covered the needs indicated by the General Data Protection Law (*Lei Geral de Proteção de Dados* – LGPD)[20], which was reviewed and approved by the FO-UFPel Departmental Council.

Full implementation

Considering the low community participation during the testing phase with fictitious data, great emphasis was placed on conducting training in workshop format. Training sessions were conducted in two-hour sessions, adapted to the specific needs of each audience. All undergraduate classes at FO-UFPel and the professors responsible for clinical disciplines and internships participated in the training, which addressed, in a practical way, the main functionalities of the system. In addition, specific training was carried out for professors, administrative technicians, and support teams, such as the radiology sector, to ensure the effective use of the system's tools related to their duties. These training activities proved essential to ensure the leveling of users and to promote greater reliability and adherence to institutional needs during the definitive implementation of the system.

Tables 1, 2, and 3 present the quantitative results related to the full implementation during the period of approximately six months (November 2024 to April 2025). However, considering that errors could occur during implementation, it was recommended that all physical and electronic records/forms be completed so that, in case of errors in testing the electronic system, there would be no damage to patient data or to the care provided.

Evaluation of user perception

Table 4 presents user perceptions of the initial implementation of the electronic information management system. The data indicate a divided perception regarding individual and institutional efficiency: 36% of participants reported improvements in their own activities, while 32% disagreed or strongly disagreed. For the efficiency of the Dental School, the positive perception was slightly lower (32%), with 34% remaining neutral. Despite this, participants demonstrated greater optimism regarding the system's potential: 50% believe it can reduce waiting lines and increase the effectiveness of services, and 46% see a positive impact on student learning. The system's usefulness in institutional management (inventory, waiting lines, referrals) was widely recognized, with 76% agreeing or strongly agreeing.

The analysis of the responses obtained in the questionnaire applied to system users also allowed us to identify the main internal and external factors that impact the implementation process. Chart 1 presents a SWOT matrix, summarizing the strengths, weaknesses, opportunities, and threats associated with the adoption of the electronic system at FO-UFPEL. The data highlight the potential of digitalization to improve organization, information security, and integration between sectors, but also reveal challenges, including structural limitations and resistance to change.

Table 1. Description of administrative and academic records during the full implementation phase of the Electronic Clinical Information Management System at a dental school – 2025.

	In loco testing	6 months of implementation
Administrative records		
Patients	18,955	20,234
Users	675	783
Appointments	2,260	6,462
Outpatient Procedures Bulletin (BPA)	4,457	13,030
Services provided	2,142	5,381
Internal regulations processed	391	1,387
Referrals processed	1,020	2,366
Sterilization entries/exits	333	3,581
Academic records		
Student/patient link		
Total	1,099	2,574
Active	888	1,081
Inactive	211	1,493
Evaluation of services	1,668	4,761

Source: Authors.

Table 2. Description of patient-related records during the full implementation phase of the Electronic Clinical Information Management System at a dental school – 2025.

	In loco testing	6 months of implementation
Patient-related records		
Interactive interview	140	408
Odontogram	30	44
Treatment plans	256	522
Removable partial denture planning	49	78
Intra-radicular retainer	7	10
Fixed prosthesis	2	4
Endodontics	24	72
Attached exams	797	2,990
Inclusion of Free and Informed Consent Form (FICF) in accordance with the General Data Protection Law (LGPD)	638	1,412

Source: Authors.

Discussion

This study aimed to describe the development and implementation of a patient information system at a Brazilian public university. Unlike other countries, which have laws that encourage the digitization of health records[21], there is still no electronic medical record tool or system that is suitable for the daily routine of Dental Schools and/or Courses. Specifically regarding medical records, different types of data collection are mentioned in the literature, ranging from direct typing into the system, electronic transcription from audio recordings, and copying data from

Table 3. Description of data related to the waiting list during the full implementation phase of the Electronic Clinical Information Management System at a dental school – 2025.

	In loco testing	6 months of implementation
Waiting List		
Total	10,198	12,173
On hold	6,218	5,867
In progress	1,283	2,403
Discharged	1,105	1,321
Cancelled	1,066	1,629
Abandoned/withdrawn	17	65

Source: Authors.

physical medical records. The system described in this study adopted the direct typing strategy, which, despite being considered the least efficient strategy, is the most commonly used[22].

Although the rates of missing data in electronic medical records can also be high[23], the literature reports that lower rates of information loss are found in electronic medical records when compared with paper medical records[23,24]. It is well-known that there are high percentages of agreement when both forms of patient records are performed[24], indicating that, whenever possible, institutions should migrate to this form of record-keeping. Furthermore, the use of electronic health records allows for the unification of clinical data and patient examinations, as well as simultaneous access by different users. This is a significant factor, as it enables rapid access to information, care coordination, error reduction, improved clinical and administrative decision-making, optimized management of waiting lists, data security, and integration with the University's academic system[8]. These benefits align with the constitutional principles of economy and efficiency[25], contributing to a more efficient and higher-quality provision of healthcare services.

The implementation of electronic information systems can be affected by the format of the proposed system, and collaborative development with the healthcare professionals who will use it can facilitate the incorporation of all relevant outcomes, usability, and clinical routines[26]. The structured approach to implementation, combined with training and support for users, allowed the system presented in this study to be efficiently integrated into the academic and administrative routines at FO-UFPel, contributing to the consolidation of planned workflows and to the improvement of user experience when using the tool.

According to user perception, the analysis of the data obtained led to the identification of areas for improvement and necessary adjustments to ensure the continuous evolution of the system and its alignment with the demands of FO-UFPel, but more importantly, it highlighted the importance of conducting periodic training sessions as a tool for training and to facilitate the use of the system. Although the perception results were mostly positive, the qualitative analysis identified users with perceptions ranging from completely favorable to reluctant to use the system, with questions related to the difficulty of use and the system's security. In a similar study conducted with nurses, Tubaishat[27] identified similar perceptions, suggesting that these problems may be related to problems with the system itself or to a lack of training. In this sense, our results reinforce the aforementioned findings,

Table 4. User perception after the initial implementation phase of the Electronic Clinical Information Management System in a dental school – 2025.

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Have you noticed any improvement in the efficiency of your activities after implementing the system?	12%	24%	28%	28%	8%
Have you noticed any improvement in the efficiency of the Dental School's activities after implementing the system?	10%	22%	34%	30%	4%
Do you believe the system can be useful for reducing waiting lists and improving the resolution of dental cases handled?	20%	30%	36%	12%	2%
Do you believe the system can be useful for improving the learning of Dental School students working in clinics?	18%	28%	44%	8%	2%
Do you believe the system can be useful to better manage the activities carried out by the Dental School (inventory control, waiting list control, referrals, patient care, etc.)?	36%	40%	24%	-	-
Do you believe that periodic training is important to improve the use of the system?	50%	44%	2%	2%	2%

Source: Authors.

Chart 1. SWOT matrix regarding the implementation of the Electronic Clinical Information Management System in a dental school – 2025 (n = 150).

STRENGTHS	WEAKNESSES
- Reduced waiting times and increased efficiency in service	- Lack of computers, tablets, and adequate physical infrastructure in clinics
- Elimination of lost medical records and paper savings	- Unstable internet connection; power outages
- Remote access to information, single and centralized history	- Lack of training and resistance from users
- Faster service and record keeping	- System still in the adaptation and partial implementation phase
- Standardized organization of clinical and administrative workflows	- Incomplete and inadequate completion due to lack of culture and commitment
- Robust base for generating epidemiological and administrative data	- Difficulty completing forms via mobile phone; absence of an application
- Communication and integration among departments, students, patients, and professors	- Low adoption rate among older users
- Security and traceability of clinical and academic data	- Lack of clarity regarding profiles and permissions within the system (e.g., radiology, sterilization)
- Greater control over treatments, referrals, and use of materials	- Overload of tasks and a feeling of function replacement by automation
- Transparency and ease of accountability to public bodies (SUS, city hall)	- Lack of alignment among triage, teachers, and users
OPPORTUNITIES	**THREATS**
- Creation of a large database for teaching, research, and management	- Digital security risks (e.g., hackers, backup integrity)
- Possibility of using data for planning and strategic decision-making	- Low adoption or continuous resistance can compromise the system's effectiveness
- Strengthening the institutional image through modernization and innovation	- Dependence on still fragile technological infrastructure
- Optimization of purchases, inventory control, and use of materials	- Hasty implementation without full engagement from professionals
- Monitoring and improvement of patient satisfaction	- Disorganization in clinical routine if there is no adequate standardization and oversight
- Recording of care for audits and quality indicators	- Institutional culture still rooted in the paper/ manual model
- Implementation of an app or mobile interface to facilitate field use	- Possible increase in bureaucracy if the system is not user-friendly
- Consolidation of a single, secure medical record with restricted and validated access	- Conflicts over responsibilities in filling out and approving information

Source: Authors.

with 94% of respondents believing that periodic training is important to improve the use of the system. The implementation of an electronic data management system also enables significant progress in the organization and efficiency of the Dental Specialty Centers (*Centros de Especialidades Odontológicas* – CEOs) within the Dental School, by allowing for the precise and real-time recording of procedures performed, as well as a detailed monitoring of care data and waiting lists. This computerization contributes to a more reliable accounting of the activities carried out, thus favoring transparency and evidence-based decision-making. Furthermore, improved management can enable the CEO to change levels, according to the criteria of the Ministry of Health, allowing for the expansion of services offered and an increase in the funding allocated to the institution, in turn strengthening its capacity to provide care and its impact on the oral health of the population. The combination of qualitative evaluation, through user perception, and quantitative analysis, based on data extracted directly from the system, was es-

sential to understand the scope of the changes promoted by the implementation of the Oxygen system.

Although the results demonstrate that the system had a strong impact on improving dental healthcare services for the population, some limitations were identified and should be considered by managers seeking to computerize Dental Schools or Basic Health Units (BHUs). In this sense, although the creation of mandatory fields has the positive aspect of preventing the loss of relevant information, several studies suggest that the increased time spent filling out electronic medical records can negatively impact the quality of care provided[28,29].

Finally, future perspectives include the use of machine-learning and artificial intelligence (AI) tools to predict demands, service-related costs, and automated analyses of flows and data accounting. In addition, there is a prospect of developing new functionalities and adapting the system so that all of the Unit's needs can be met.

FO-UFPel is part of the SUS service network, registered with the Ministry of Health as a Type I CEO. Therefore, it acts as a referral center for dental specialties in the municipality of Pelotas and receives patients referred by the municipality's regulatory system. This electronic information management system has improved the monitoring of the therapeutic itinerary of patients accessing FO-UFPel via municipal regulation until clinical discharge. As it is a teaching clinic, numerous internal referrals are made between different disciplines and specialties. It is possible to speculate that, with this electronic system, the management of waiting lists for different specialties will be more efficient, thus reducing the number of duplicate requests, and monitoring requests throughout all clinical events will enable a significant increase in the number of completed requests and/or patients discharged. Furthermore, improvements were observed in communication between the triage sector and the students, and between the municipal regulatory system and FO-UFPel, as well as in accountability and productivity.

The electronic information management system has implemented modules that allow for the detailed recording of patients' oral health conditions and represents important advances compared to other health information record systems that restrict patient-student linking, lack a subject evaluation system, and do not have specific clinical examination modules. The evaluation of students and teachers incorporated by the system is also an extremely important innovation for teaching clinics, which also has the prospect of being used as a reference for patient information record systems, such as eSUS-AB.

A possible example of the applicability of the current information system could be the *Mais Médicos* (More Doctors Program, which currently has 28,000 positions for doctors in Brazil. These doctors are hired and required to undergo supplementary training and receive visits from tutors. Although supplementary training is mandatory, there is no effective way to monitor the clinical performance of these professionals[30]. This gap can also be observed for the thousands of multidisciplinary or family and community medicine residencies distributed throughout the country. In this respect, modules that allow for monitoring and interaction within an electronic medical record could bring significant advances in the training of these professionals and in the quality of care.

Limitations in the development and implementation of the tool

The following limitations of the tool can be listed: 1) an internet connection is required for the tool to run. Additionally, it requires space on online cloud services for the system to store the entered data, resulting in additional service costs; 2) for the implementation phase, extensive training is necessary for all those involved; and 3) the lack of certification for electronic health record systems is a potential limitation. Although the Federal Council of Dentistry does not require or regulate this, such certification could be important to improve data quality and information security in the future.

Conclusion

Considering the quantitative results combined with the favorable perception of users, it can be concluded that the system demonstrates viability and effectiveness for academic and administrative management. However, to guarantee the full functioning and sustainability of the system, it is essential to carry out periodic training and capacity building, as well as establish institutional regulations that ensure adherence to the established workflows. In this way, it will be possible to avoid breakdowns in processes and guarantee the uniformity and efficiency of operations.

Collaborations

PAM Nunes: system development, data collection and interpretation, drafting of the article. FWMG Muniz, K Collares and OP D'Avila: member of the macro and subprocess discussion groups, interpretation of results, drafting of the article. MBF Santos: original idea, system development, data collection and interpretation, drafting of the article, project coordinator.

Ackknowledgements

Dr. Muniz is a fellow of the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

Data availability statement

The data sources adopted in the research are indicated in the article's body.

References

1. Tsai J, Bond G. A comparison of electronic records to paper records in mental health centers. *Int J Qual Health Care* 2008; 20(2):136-143.
2. Asgari I. Development an electronic oral health record application for educational dental setting. *J Educ Health Promot* 2018; 7:124.
3. Fernandes L, Machado R, GO A. Gerência de serviços de saúde: competências desenvolvidas e dificuldades encontradas na atenção básica. *Cien Saude Colet* 2008; 14(Supl. 1):1541-1552.
4. Santos TO, Pereira LP, Silveira DT. Implantação de sistemas informatizados na saúde: uma revisão sistemática. *Reciis* 2017; 11(3):1-11.
5. Montague E. The promises and challenges of health information technology in primary health care. *Prim Health Care Res Dev* 2014; 15(3):227-230.
6. Jeffries M, Phipps D, Howard RL, Avery A, Rodgers S, Ashcroft D. Understanding the implementation and adoption of an information technology intervention to support medicine optimisation in primary care: qualitative study using strong structuration theory. *BMJ Open* 2017; 7(5):e014810.
7. Vaz GP, EL B. Impactos do processo de informatização para o ensino e funcionamento dos serviços em saúde: um relato de experiência. *Rev Patol Tocantins* 2020; 7(1):130-135.
8. Luz TSML. P*roposta de implantação de prontuário eletrônico na equipe de Saúde da Família Rua Nova no município de Marechal Deodoro-AL* [monografia]. Uberaba: Universidade Federal do Triângulo Mineiro; 2017.
9. Object Management Group (OMG). *Business Process Model and Notation (BPMN), version 2.0*. Needham: Object Management Group; 2011.
10. Miro. AI Innovation Workspace [Internet]. [cited 2025 ago 3]. Available from: https://miro.com/
11. Doğan S, Betin-Can A, Garousi V. Web application testing: A systematic literature review. *J Syst Softw* 2014; 91:174-201.
12. Nunes PAM, Santos MBF. Sistema Oxigênio de Informações [Internet]. 2024 [acessado 2024 out 13]. Disponível em: https://oxigenioufpel.com.br/
13. Gürel E, Tat M. SWOT analysis: A theoretical review. *J Int Soc Res* 2017; 10(51):994-1006.
14. World Wide Web Consortium (W3C). HyperText Markup Language (HTML) [Internet]. 2025 [citedo 2025 ago 3]. Available from: https://www.w3.org/TR/html5/
15. World Wide Web Consortium (W3C). Cascading Style Sheets Level 2 Revision 1 (CSS 2.1) specification [Internet]. 2011 [cited 2025 ago 3]. Available from: https://www.w3.org/Style/CSS/Overview.en.html
16. Flanagan D, Matilainen P. *JavaScript*. Anaya Multimedia; 2007.
17. Bakken SS, Suraski Z, Schmid E. *PHP manual*. New York: iUniverse, Incorporated; 2000.
18. Bourhis P, Reutter JL, Vrgoč D. JSON: Data model and query languages. *Inf Syst* 2020; 89:101478.
19. Slazinski ED. Structured Query Language (SQL) [Internet]. 2004 [cited 2025 ago 3]. Available from: https://doi.org/10.1002/047148296X.tie166
20. Brasil. Presidência da República. Lei nº 13.709, de 14 de agosto de 2018. Lei Geral de Proteção de Dados Pessoais. *Diário Oficial União* 2018; 15 ago.
21. USDoHaH. HITECH Act enforcement interim final rule [Internet]. 2009 [cited 2020 fev 25]. Available from: http://www.hhs.gov/ocr/privacy/hipaa/administrative/enforcementrule/hitechenforcementifr.html
22. Exeni McAmis NE, Dunn AS, Feinn RS, Bernard AW, Trost MJ. Physician perceptions of documentation methods in electronic health records. *Health Informatics J* 2021; 27(1):1460458221989399.
23. Bounthavong M, Watanabe JH, Sullivan KM. Approach to addressing missing data for electronic medical records and pharmacy claims data research. *Pharmacotherapy* 2015; 35(4):380-387.
24. Masoe AV, Blinkhorn AS, Colyvas K, Taylor J, Blinkhorn FA. Reliability study of clinical electronic records with paper records in the NSW Public Oral Health Service. *Public Health Res Pract* 2015; 25(2):e2521519.
25. Brasil. *Constituição da República Federativa do Brasil*. Brasília: Senado Federal; 2016.
26. Bagayoko CO, Tchuente J, Traoré D, Moukoumbi Lipenguet G, Ondzigue Mbenga R, Koumamba AP, Ondjani MC, Ndjeli OL, Gagnon MP. Implementation of a national electronic health information system in Gabon: a survey of healthcare providers' perceptions. *BMC Med Inform Decis Mak* 2020; 20(1):202.
27. Tubaishat A. The effect of electronic health records on patient safety: A qualitative exploratory study. *Inform Health Soc Care* 2019; 44(1):79-91.
28. Friedberg MW, Chen PG, Van Busum KR, Aunon FM, Pham C, Caloyeras JP, Mattke S, Pitchforth E, Quigley DD, Brook RH, Crosson FJ, Tutty M. Factors Affecting Physician Professional Satisfaction and Their Implications for Patient Care, Health Systems, and Health Policy. *Rand Health Q* 2014; 3(4):1.
29. Manca DP. Do electronic medical records improve quality of care? Yes. *Can Fam Physician* 2015; 61(10):846-847, 850-851.
30. Wollmann L, Pereira Avila O, H E. Programa Médicos pelo Brasil: mérito e equidade. *Rev Bras Med Fam Comunidade* 2020; 15(42):2346.

Article submitted 08/05/2025
Approved 18/12/2025
Final version submitted 20/12/2025

Chief editors: Maria Cecília de Souza Minayo, Romeu Gomes, Antônio Augusto Moura da Silva, Vania de Matos Fonseca