UNIVERSIDADE DE CAXIAS DO SUL – UCS

PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO

PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA SAÚDE

LEONARDO PELLIZZONI

ECOSSISTEMA DIGITAL DE SAÚDE: CONECTANDO BANCOS DE DADOS VERIFICADOS COM A PRÁTICA CLÍNICA E A EXPERIÊNCIA DO PACIENTE

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Tese apresentada à Universidade de Caxias do Sul, para obtenção do título de Doutor em Ciências da Saúde.

Orientador: Dr. Asdrubal Falavigna

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PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA SAÚDE

COORDENADOR DO PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA SAÚDE

PROF. DR. JOSÉ MAURO MADI

ECOSSISTEMA DIGITAL DE SAÚDE: CONECTANDO BANCOS DE DADOS VERIFICADOS COM A PRÁTICA CLÍNICA E A EXPERIÊNCIA DO PACIENTE

Tese de Doutorado submetida à Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação em Ciências da Saúde da Universidade de Caxias do Sul, como parte dos requisitos necessários para a obtenção do título de Doutor em Ciências da Saúde, Linha de Pesquisa: Computação Aplicada às Ciências da Saúde.

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RESUMO

Introdução: Os dados permitem a comparação de diferentes tratamentos clínicos em múltiplas áreas da medicina e o uso eficiente dos recursos. Patient-reported outcomes (PRO) coletam dados diretamente de pacientes. Estas informações são utilizados na prática clínica, auxiliando na tomada de decisão. Atualmente existem trabalhos que ressaltam a importância da comunicação multicanal (WhatsApp, e-mail, SMS) com profissionais da saúde e principalmente pacientes. A comunicação multicanal é conhecida como omnichannel no varejo e possibilita integrar diferentes canais de comunicação com o objetivo de melhorar a experiência do cliente final, seja ele paciente, profissional da saúde ou um cliente em compras. Adicionalmente aos meios de comunicação a prática diária dos profissionais de saúde demanda atividades diferentes e gera dados não estruturados. Entre estas atividades temos consultas por videochamadas, registro de consultas e controle de questionários de acompanhamento e monitoramento. A existência de vários sistemas separados para diferentes atividades na prática médica pode resultar em complexidades e gargalos no uso por parte dos profissionais da saúde e pacientes.

Objetivo: Apresentar o ecossistema digital de saúde que unifica a pesquisa cientifica com a prática médica em múltiplos canais de comunicação. Criar mecanismos de verificação, autenticidade e integridade dos dados coletados e armazenados.

Metodologia: As demandas e necessidades do sistema foram obtidas utilizando a metodologia de desenvolvimento Iconix. Utilizou-se o Mircrosoft .NET para manter as funcionalidades já existentes e para criar as novas funcionalidades do sistema. A usabilidade, utilidade e satisfação do usuário em relação ao sistema foi medida através do questionário Post-Study System Usability Questionnaire (PSSUQ).

Resultados: As novas funcionalidades e mecanismos adicionados ao sistema permitiram que múltiplos canais de comunicação fossem utilizados para comunicar-se com pacientes e profissionais da saúde. Os novos canais de comunicação como WhatsApp, E-mail e SMS permitiram o acompanhamento autônomo. Um único sistema possibilitou realizar consultas por vídeo, registro e anotações das consultas com os pacientes e coletar dados de questionários estruturados via link e chatbot. As funcionalidades criadas no ecossistema permitiram fazer a verificação, integridade e autenticidade dos dados coletados e armazenados.

Conclusão: Este trabalho utilizou múltiplos canais de comunicação, como WhatsApp, E-mail e SMS, para interação autônoma com pacientes e profissionais da saúde via link e chatbot. Foram utilizados e armazenados dados estruturados e não estruturados que puderam ser verificados e autenticados.

Palavras-chave: Chatbot; Omnichannel; Patient Reported Outcomes; Bancos de dados; Prontuários médicos; Telemedicina.

ABSTRACT

Introduction: Databases allow the comparison of different clinical treatments in multiple areas of medicine and the efficient use of resources. Patient-reported outcomes (PRO) collect data directly from patients. This data is used in clinical practice, aiding decision-making. There are currently studies highlighting the importance of multichannel communication (WhatsApp, email, SMS) with healthcare professionals and especially patients. Multichannel communication is known as omnichannel in retail and makes it possible to integrate different communication channels with the aim of improving the experience of the end customer, be they a patient, a healthcare professional or a shopping customer. In addition to the means of communication, the daily practice of healthcare professionals requires different activities and generates unstructured data. These activities include video call consultations, recording consultations and controlling follow-up and monitoring questionnaires. The existence of several separate systems for different activities in medical practice can result in complexities and bottlenecks in use by healthcare professionals and patients.

Objective: To present the Digital Health Ecosystem (DHE) that unifies scientific research with medical practice in omnichannel communication and mechanisms for authenticity and integrity verification of collected and stored data.

Methodology: The system requirements and needs were met utilizing the Iconix development methodology. Microsoft Net was used to develop software. Usability, usefulness and user satisfaction with the system were measured using the Post-Study System Usability Questionnaire (PSSUQ).

Results: Omnichannel communication was utilized to contact patients and healthcare professionals autonomously. A single system enabled the carrying out of patient-reported outcome data collection, telemedicine, image storage, and notes from patient consultations. The data was collected through structured questionnaires via link and chatbot. The functionalities created in the HDE allowed for the integrity and authenticity verification of the data collected and stored.

Keywords: Chatbot; Omnichannel; Patient Reported Outcomes; Database; Medical records; telemedicine

LISTA DE FIGURAS

LISTA DE ABREVIATURAS E SIGLAS

API	Application Programming Interface
ASP	Active Server Pages
ATS	Avaliação de Tecnologias em Saúde
CSV	Comma-separated values
DHE	Digital Health Ecosystem
EQ5D	Euro Quality of Life 5 Dimensions
IP	Internet Protocol
N²QOD	National Neurosurgery Quality and Outcomes
ODI	Oswestry Disability Index
PDF	Portable Document Format
PRO	Patient-reported outcomes
PSSUQ	Post-Study System Usability Questionnaire
TI	Tecnologia da Informação
SPSS	Statistical Package for the Social Sciences
SQL	Structured Query Language

SUMÁRIO

1 INTRODUÇÃO

Um conjunto de dados possibilita que a avalição de tecnologias em saúde (ATS) compare diferentes tratamentos clínicos em múltiplas áreas da medicina e a utilização eficiente de recursos (1). Uma das formas de criar-se um conjunto de dados é por meio de questionários como os Patient Reported Outcomes (PRO), que coletam dados diretamente do paciente sem a necessidade de terceiros (2). Os dados coletados através de questionários são utilizados para auxiliar na tomada de decisão, mensurar critérios de eficácia, acurácia e efetividade da atividade diária do profissional da saúde e de qualidade de vida dos pacientes (3,4).

Apesar dos pacientes se mostrarem engajados em responderem os questionários quando a utilidade da informação é comprovada (5), existem algumas barreiras que impedem a utilização dos PRO: falta de tempo, falta de assistência na coleta dos dados, longo tempo de preenchimento dos questionários pelos pacientes e a falta de um banco de dados (6). A utilização de sistemas para auxiliar estes e outros aspectos de modo a acompanhar e avaliar tratamentos clínicos já é documentada e utilizada (7), no entanto, para o contexto dos PRO faz-se necessário sistemas flexíveis, que permitam um delineamento dos questionários de acordo com a população e práticas clínicas (8).

Neste contexto desenvolveu-se de 2016 até 2018 um software que possibilita criar bancos de dados da saúde e auxiliar na coleta dos dados. O software se comunica via e-mail diretamente com pacientes e médicos que precisam responder algum questionário conforme o delineamento clínico definido (9). O software desenvolvido foi disponibilizado na internet e acessado por celular, tablet ou computador por um grupo restrito de usuários de testes com a finalidade de realizar a validação final do sistema.

A versão inicial do software permitiu comunicar-se com pacientes e profissionais da saúde via e-mail de forma automática (9). Alguns trabalhos sugerem a importância de haver a comunicação multicanal com profissionais da saúde e principalmente com pacientes, interagindo com eles via SMS, WhatsApp ou outras redes sociais (10–12). A comunicação multicanal é uma estratégia conhecida também como omnichannel no varejo e permite integrar diferentes canais de comunicação com o objetivo de melhorar a experiência do cliente final, seja ele paciente, profissional da saúde ou um cliente em compras (13).

Além da comunicação multicanal outro fator relevante é a prática diária dos profissionais de saúde, que realizam consultas e acompanhamentos com os pacientes. Frequentemente as atividades realizadas pelos profissionais de saúde geram novos conjuntos de dados não estruturados e que também são informações relevantes do paciente (14). Tipicamente existe uma separação entre sistemas utilizados na prática médica, um que realiza a coleta de questionários padronizados, outro que faz o registro de consultas e talvez um terceiro para vídeo chamadas, gerando vários softwares que realizam uma tarefa cada (15). Vários sistemas podem gerar complexidades e gargalos na utilização por parte dos profissionais da saúde.

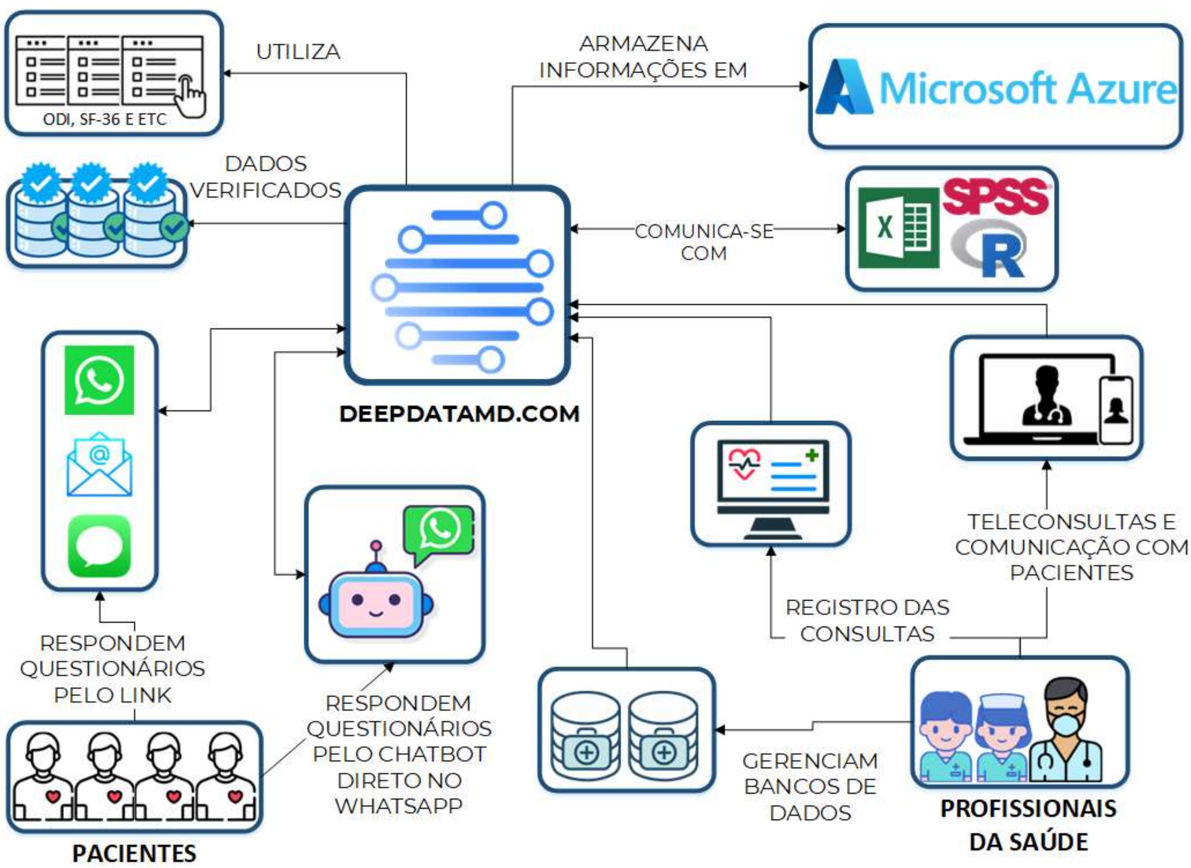

Figura 1 Ecossistema digital de saúde e suas funcionalidades

Os objetivos deste trabalho foram: (1) propor e apresentar o ecossistema digital de saúde que unifica a pesquisa cientifica com a prática médica em múltiplos canais de comunicação, (2) propor mecanismos de verificação, autenticidade e integridade dos dados coletados e armazenados e (3) avaliar a usabilidade e a utilidade percebida pelos profissionais de saúde que usaram o ecossistema. Neste aspecto o APÊNDICE A – ARTIGO I aborda o ecossistema de dados proposto, implementado e em uso que está representado na Figura 1. No APÊNDICE B – ARTIGO II está o artigo que trata os meios e formatos de disponibilidade do ecossistema, bem como as estruturas de técnicas que compõem a arquitetura de software do ecossistema. Os comprovantes de submissão de cada artigo estão no ANEXO 1 – COMPROVANTE DE SUBMISSÃO DO ARTIGO I e no ANEXO 2 – COMPROVANTE DE SUBMISSÃO DO ARTIGO II.

2 LIMITAÇÕES DO ESTUDO

O trabalho apresenta limitações que se referem a complexidade na utilização do WhatsApp de forma automatizada através da API (Application Programming Interface) oficial fornecida e disponibilizada pelo Grupo Meta. Esta complexidade torna necessário uma equipe multidisciplinar da área da Tecnologia da Informação (TI). Outra limitação refere-se as mudanças e melhorias nas regras da API do WhatsApp, exigindo assim a necessidade de readequações ou novas implementações para manter-se em conformidade com o exigido.

3 PERSPECTIVAS FUTURAS

A inclusão de novos canais de comunicação para contato com profissionais da saúde e principalmente pacientes é uma das possibilidades a serem exploradas para o futuro. Estes novos canais de comunicação podem ser já existentes como Instagram, Telegram e LinkedIn ou novos meios de contato que venham a ser criados e utilizados pelas pessoas.

Considerando que o trabalho já possibilita interagir com os pacientes por áudio existiria uma linha de comunicação alternativa que poderia utilizar dispositivos e assistentes de voz como por exemplo Alexa, Siri, Apple HomePod, Google Assistente entre outros. A interação através destes dispositivos e assistentes poderia auxiliar pessoas com deficiência no preenchimento dos dados de acompanhamento médico.

Adicionalmente, por se tratar de um ecossistema de dados outras integrações com equipamentos como relógios inteligentes ou pulseiras de monitoramento poderiam agregar valor no acompanhamento dos pacientes.

4 CONSIDERAÇÕES FINAIS

As novas funcionalidades e mecanismos adicionados ao sistema permitiram que múltiplos canais de comunicação fossem utilizados para comunicar-se com pacientes e profissionais da saúde. Os novos canais de comunicação como WhatsApp, E-mail e SMS permitiram o acompanhamento autônomo com pacientes em questionários padronizados e consultas médicas. Conseguiu-se no mesmo sistema a interligação entre atividades da prática clínica com a criação e manutenção de múltiplos bancos de dados e a comunicação com o paciente através de vídeo chamadas. O sistema possibilitou que bancos de dados estejam integrados com canais de comunicação como WhatsApp e permitiram pacientes responder questionários diretamente no próprio aplicativo de conversa, em um formato de chatbot. Neste trabalho foi possível utilizar o mesmo sistema para coletar e gerenciar questionários de diferentes domínios da saúde de forma flexível. Realizou-se a verificação, autenticidade e integridade dos bancos de dados criados através de um processo disponibilizado no próprio sistema fazendo uso de algoritmos de Checksum SHA512.

REFERÊNCIAS

1. Hogervorst MA, Vreman RA, Mantel-Teeuwisse AK, Goettsch WG. Reported Challenges in Health Technology Assessment of Complex Health Technologies. Value in Health. 2022 Jun 1;25(6):992–1001.

2. Spertus J. Barriers to the Use of Patient-Reported Outcomes in Clinical Care. Circ Cardiovasc Qual Outcomes. 2014 Jan 1;7(1):2–4.

3. Falavigna A, Teles AR, Braga GL de, Barazzetti DO, Lazzaretti L, Tregnago AC. Instrumentos de avaliação clínica e funcional em cirurgia da coluna vertebral. Coluna/Columna. 2011;10(1):62–7.

4. Falavigna A, Righesso Neto O, Teles AR. Avaliação clínica e funcional no pré-operatório de doenças degenerativas da coluna vertebral. Coluna/Columna. 2009 Sep;8(3):245–53.

5. Santana MJ, Haverman L, Absolom K, Takeuchi E, Feeny D, Grootenhuis M, et al. Training clinicians in how to use patient-reported outcome measures in routine clinical practice. Quality of Life Research. 2015 Jul 15;24(7):1707–18.

6. Teles AR, Righesso O, Gullo MCR, Ghogawala Z, Falavigna A. Perspective of Value-Based Management of Spinal Disorders in Brazil. World Neurosurg. 2016 Mar 1;87:346–54.

7. Goeree R, He J, O’Reilly D, Tarride JE, Xie F, Lim M, et al. Transferability of health technology assessments and economic evaluations: a systematic review of approaches for assessment and application. Clinicoecon Outcomes Res. 2011;3:89–104.

8. Nelson EC, Eftimovska E, Lind C, Hager A, Wasson JH, Lindblad S. Patient reported outcome measures in practice. BMJ. 2015 Feb 10;350:g7818.

9. Pellizzoni L, e Silva S de A, Falavigna A. Multilanguage health record database focused on the active follow-up of patients and adaptable for patient-reported outcomes and clinical research design. Int J Med Inform. 2020 Mar 1;135.

10. Huf S, Kerrison RS, King D, Chadborn T, Richmond A, Cunningham D, et al. Behavioral economics informed message content in text message reminders to improve cervical screening participation: Two pragmatic randomized controlled trials. Prev Med (Baltim). 2020 Oct 1;139:106170.

11. Poblete P, Nieto E. Does time matter? WhatsApp vs electronic mail for dental education. A pilot study. European Journal of Dental Education. 2020 Feb 1;24(1):121–5.

12. Blasiak A, Sapanel Y, Leitman D, Ng WY, De Nicola R, Lee VV, et al. Omnichannel Communication to Boost Patient Engagement and Behavioral Change With Digital Health Interventions. J Med Internet Res [Internet]. 2022 Nov 1 [cited 2023 Apr 16];24(11). Available from: https://pubmed.ncbi.nlm.nih.gov/36383427/

13. Moreira A, Alves C, Machado J, Santos MF. An Overview of Omnichannel Interaction in Health Care Services. Mayo Clinic Proceedings: Digital Health [Internet]. 2023 Jun 1 [cited 2023 Apr 16];1(2):77–93. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2949761223000160

14. Vest JR, Grannis SJ, Haut DP, Halverson PK, Menachemi N. Using structured and unstructured data to identify patients' need for services that address the social determinants of health. Int J Med Inform. 2017 Nov 1;107:101–6.

15. Assale M, Dui LG, Cina A, Seveso A, Cabitza F. The Revival of the Notes Field: Leveraging the Unstructured Content in Electronic Health Records. Front Med (Lausanne). 2019 Apr 17;6:439247.

APÊNDICE A – ARTIGO I

CONNECTING VERIFIED DATABASES WITH CLINICAL PRACTICE AND THE PATIENT' S EXPERIENCE THROUGH OMNICHANNEL COMMUNICATION

Leonardo Pellizzoni; Asdrubal Falavigna

ABSTRACT

Introduction: Patient-reported outcomes (PRO) collect data directly from patients. These data are utilized in clinical practice, helping decision-making. Studies emphasize the importance of omnichannel communication (WhatsApp, e-mail, SMS) with healthcare professionals and patients. Omnichannel communication enables the integration of different communication channels to improve the end-client experience. In addition to the means of communication, the daily practice of professionals requires different activities that can be performed in distinct systems. The existence of various separate systems for other activities in medical practice may result in complexities and bottlenecks in their use by healthcare professionals and patients.

Objective: To present the Digital Health Ecosystem (DHE) that unifies scientific research with medical practice in omnichannel communication and mechanisms to verify the authenticity and integrity of the data collected and stored.

Methodology: The system requirements and needs were met utilizing the Iconix development methodology. Microsoft Dot Net was used to develop software. Usability, usefulness and user satisfaction with the system were measured using the Post-Study System Usability Questionnaire (PSSUQ).

Results: Omnichannel communication was utilized to contact patients and healthcare professionals autonomously. A single system enabled the carrying out of patient-reported outcome data collection, telemedicine, image storage, and notes from patient consultations. The data was collected through structured questionnaires via link and chatbot. The functionalities created in the HDE allowed the integrity and authenticity verification of the data collected and stored.

Conclusion: Personalized omnichannel communication via links and chatbots using WhatsApp, E-mail, and SMS accelerates autonomous interaction with patients and

healthcare professionals. In addition, the structured and non-structured data were stored in the EHD and able to be verified for integrity and authenticity.

KEYWORDS
Chatbot; Omnichannel; Patient Reported Outcomes; Database; Medical records; Telehealth.

INTRODUCTION

A dataset enables the comparison of different clinical treatments and the efficient use of resources [1]. Patient Reported Outcomes (PRO) questionnaires create datasets through direct interaction with the patient [2]. The data collected helps make decisions and positively impacts the patient's quality of life [3,4].

Although the patients show commitment in answering the questionnaires when the usefulness of the information is proven [5], there are a few barriers that prevent the use of the PRO: lack of time, lack of help in the collection of the data, a long time needed for the patients to fill in the questionnaires and the lack of an electronic database [6]. Electronic systems and new technology can overcome these obstacles [7]. For the PRO data collection, it is necessary to have flexible systems that allow designing the questions according to the population, patient preferences, and clinical practices [8].

We have published the first version of the software that automatically allows communication among the Digital Health Ecosystem (DHE), patients, and healthcare professionals via e-mail [9]. Studies suggest the benefit of omnichannel communication with healthcare professionals and patients via SMS, WhatsApp, or other social networks [10–12]. Multiple-channel communication is a strategy known as omnichannel in retail and improves the end client experience [13].

Besides omnichannel communication, another relevant factor is the daily practice of healthcare professionals who carry out appointments and follow up with patients. Frequently, the activities performed by the health care professionals generate new sets of non-structured data that also are relevant information about the patient

[14]. Typically, there is a separation between the systems used in medical practice: one that collects standardized questionnaires, another that records appointments, and a third for video calls and telemedicine [15]. Several systems may generate complexities and bottlenecks when used by healthcare professionals.

The objectives of this study were (1) to present the ecosystem that unifies scientific research with medical practice using omnichannel communication, (2) to propose mechanisms that perform the verification, authenticity and integrity of the data collected and stored, and (3) to evaluate the usability and usefulness of the DHE.

METHODS

The authors previously published the methodology regarding patient information, the software architecture, the structure of questionnaires, and the information relating to the clinical studies [9].

The methodology of the new functionalities and improvements are described below.

Security control

The healthcare professional accesses the platform through a personalized user and password and two-factor authentication (2-FA) [16]. The permission level to access different platform stages was defined according to the profiles of authorizations and the responsibility in the workflow process.

Applicability and Usage

The system was evaluated using the Post-Study System Usability Questionnaire (PSSUQ), which measures the usability and satisfaction of the user regarding the system [17–19]. At least eight users reported a 96% confidence level [17–19]. The questionnaire was sent by e-mail to 41 healthcare professionals.

Active patient's follow-up

The respondent received a notice about the need for questionnaire answering by email, WhatsApp, and SMS, which contains a link to access all questionnaires.

Answering can be done by cell phone, tablet or computer. Besides filling in the questionnaire, a chatbot WhatsApp conversation was initiated between the patient and the system. The questions were sent using text or audio format according to the patient's preference. The notifications and reminders to the patients to fill in the questionnaire were performed daily. The system manages the patient data collection agenda according to the entry date or intervention.

Authenticity and integrity data verification

Confirming the integrity and authenticity of files was essential to show credibility, origin and traceability [20,21]. In the present study, the Hash SHA512[1] algorithm promotes the authenticity and integrity of the data collected and exported. The authenticity of the answers filled in by patients and healthcare professionals was obtained using the IP addresses and geolocation.

Managing WhatsApp notifications

The availability of output messages was evaluated by conducting tests by sending WhatsApp messages and monitoring their receipt and visualization. Two tests were utilized, the first with a welcome message and the second with an Opt-in[2] mechanism with the possibility of a pre-defined answer. The tests measured how the message contents were visualized by patients and whether the link sent was still available and accessible (highlighted in blue). The WhatsApp version utilized in Android cell phones was 2.22.24.78, and for iPhones, 2.22.24.81. In none of the cases was the cell phone number of the automated sends saved as the contact on the cell phone that received the messages. Each test was conducted with a different person and phone number. No person or number has previously been used to send automated messages by the system.

RESULTS

[1] https://datatracker.ietf.org/doc/html/rfc6234
[2] https://developers.facebook.com/docs/whatsapp/overview/getting-opt-in/?locale=en

This section presents the results of the DHE separated into subsections according to each functionality.

Patients

The patients registered in the DHE can be in one of the data structures, Medical Records, Study Databases, or both. This structure allows registering the patient in the medical records to insert all appointment notes and, simultaneously, to participate in one or more clinical databases. Each healthcare professional visualizes the contents of the medical records and databases according to the previously configured levels of security and control. The group of physicians decides if it will be allowed to visualize patients from other centers or only the patients entered by the individual surgeons. There is no limit to the records and databases. Once the patients are inserted into medical records and databases, they cannot be removed.

The separation between the patients in the medical records and those in the databases allows direct and semiautomatic interaction between the non-structured data of the patient's appointments and the structured and standardized data of the PROMs and specific follow-up questionnaires.

The health care professional begins to insert the patient in the medical records, fill in the appointment notes, and then choose the databases where the patient will participate. After that, the system automatically inserts the patient in each database utilizing the information from the medical record. The DHE displays the single code of the patient in each database inserted.

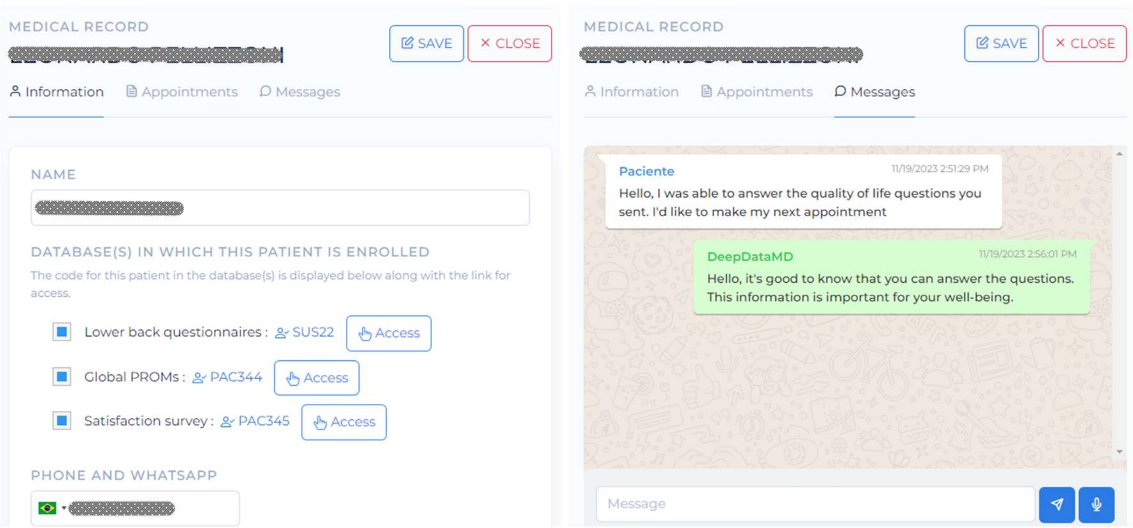

Figure 1 – Left side: Medical Record of a test patient participating in three databases. Right side: Message guide for communication with the patient via WhatsApp.

The patient flow created allows registering the patient a single time in the system and later including them in new databases according to need or even creating a new database that will appear automatically in the medical records. Another point to be highlighted is the centralization of the data, allowing the physician to access all databases of that case, even if they have different codes, different databases, or are created at other times. The DHE also allows for centralizing the data of the appointments and messages exchanged with the patient.

Communication with patients via WhatsApp messages

In addition to the communication programmed and controlled automatically by the system for filling in the questionnaires, a communication channel was created for health professionals to talk directly to the patient via WhatsApp (Figure 1, right side). The system allows healthcare professionals in patient care to send text or audio messages directly using the Messages box of the patient's medical record.

The flow of communication is reciprocal and allows both patients and healthcare professionals to interact with each other. When the patient initiates a conversation, the health care professionals are informed there are messages to answer by a red notification next to the patient's name. The patient can also send photos, videos and audio messages through WhatsApp that appear on the DHE.

Teleappointments

The DHE system allowed the health care professional to attend to the patient via video calls or telehealth. Up to 10 people can participate in telehealth without installing any app or software. The procedure is performed in two steps only. First, the healthcare professional sends the access link to the patient's WhatsApp, email, or SMS, along with the date and time of the appointment (Figure 2). Second, the patient clicked or tapped on the link and opened a standard navigator window to begin attending online.

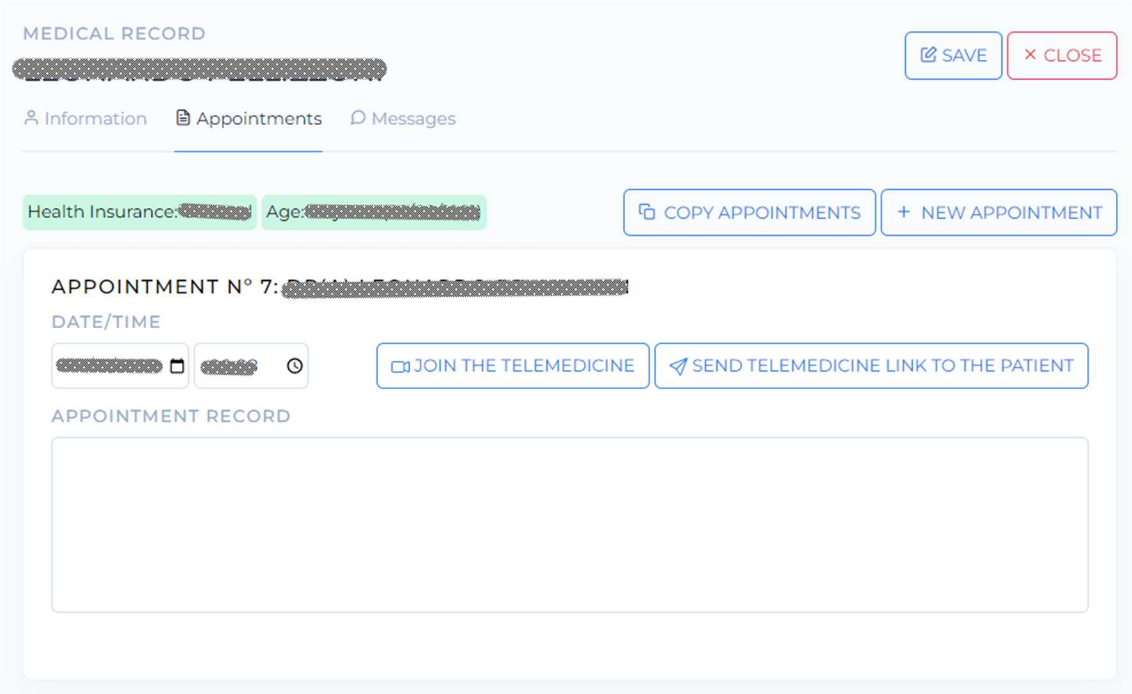

Figure 2 - Visualization of the patient's appointments and access to telemedicine.

The fact that it does not require any installation or login mechanisms with a user and password does not make the teleappointment system insecure. An inbuilt security control in the links sent utilizes randomized keys, and all information exchanged is encrypted. The data saved in the system was stored in an encrypted form.

Active follow-up of the patients.

The patients and the health professionals with pending questionnaires were notified by email or WhatsApp, as defined by the database properties. The system sends the messages in the patient’s language with a link that enables accessing and answering all the pending questionnaires. Figure 3 illustrates a patient's notifications through WhatsApp and email requesting them to answer the questionnaires.

The patient does not need a username and password to answer the questions since security is controlled via a security key built into links sent. Each link sent has a different security key, even if for the same patient, indifferently to the number of questionnaires to be answered in the same period. When a questionnaire is concluded, the system automatically initiates the following questionnaire if there is one.

The questions are exhibited once, and selecting an option automatically displays the next question. The next question is visualized only in single-choice questions, and it is possible to return to the previous ones.

The DHE controls loss via notifications to the health care professionals when the patient does not answer the questionnaires, and five days are lacking the end of the answering window. Simultaneously, emails and WhatsApp messages are sent to the professionals responsible for that patient. The active follow-up occurs similarly when the healthcare professional must complete the questionnaires.

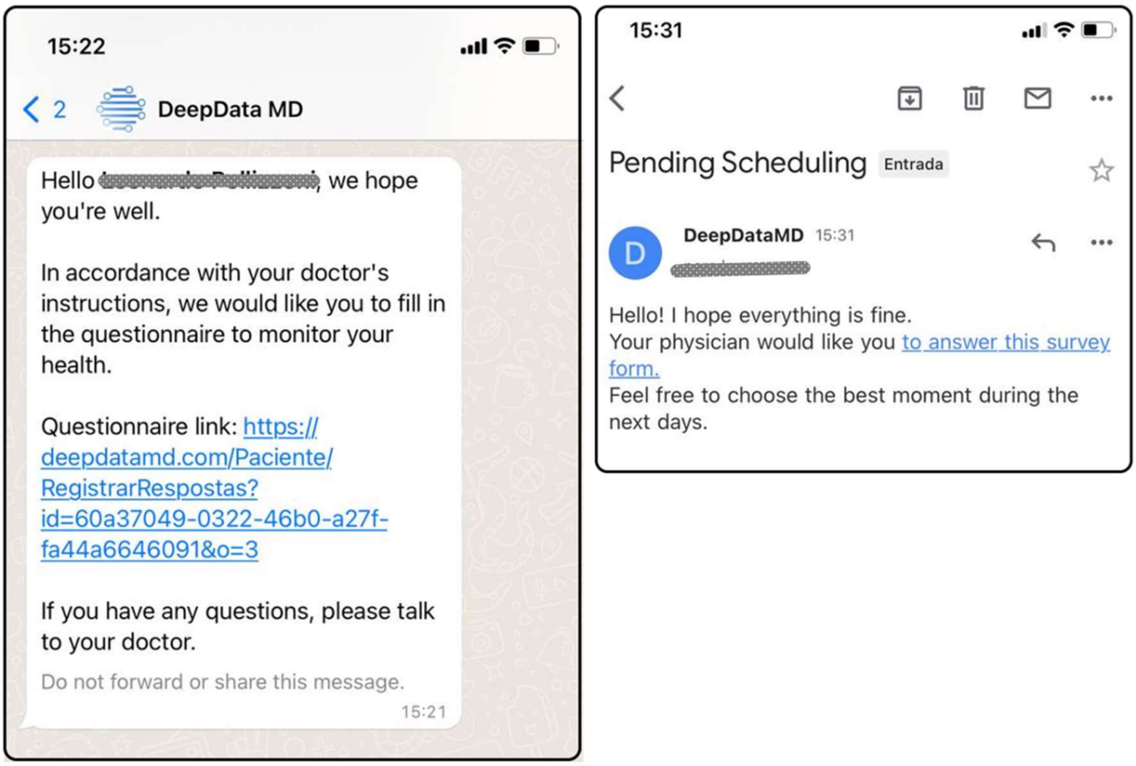

Figure 3 - Messages sent to the patient's WhatsApp and e-mail so they will answer the questionnaires via link without username and password.

The link of access to the questionnaires needs to be more valid when data collection ends or access is performed outside the period for acceptance of answers. In those cases, the reason is informed to the patient by messages.

Chatbot to collect questionnaires.

Data collection via chatbot allowed interaction with the patient directly in a conversation via the WhatsApp app. The chatbot simulated an exchange of messages between two persons requesting the answers to the questionnaires that should be answered and waiting for the answers. For this data collection channel, the patient could choose how they would like to receive the questions: in text or audio (Figure 4). The patient was also allowed to select the answers on another day and at their chosen time. In the scenario in which they decide to answer later, the system will remind them at the selected time.

The messages' order followed the questionnaire design for each database. With each answer the patient sends via WhatsApp, the system is stored in the database, creating the connection between the question, questionnaire, collection schedule, patient, and database. The exchange of messages with the patient via WhatsApp is entirely autonomous and does not require human intervention. The audios referring to the questions were pre-recorded. The texts and options of the questions are the same as visualized in the navigator of the patients’ cell phones when the questionnaire is accessed via the link.

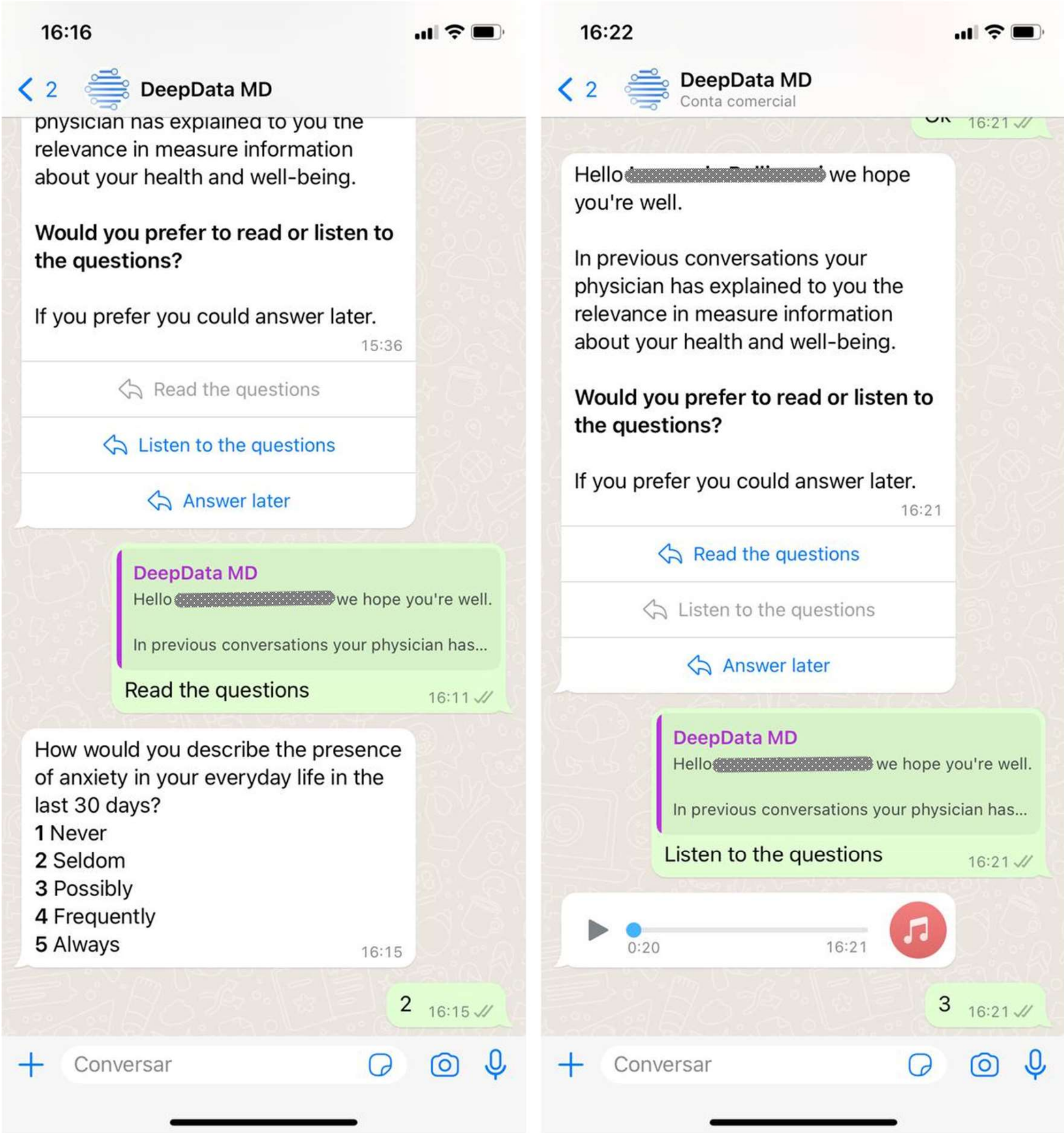

Figure 4 - The questionnaire collection process starts directly in a WhatsApp conversation controlled automatically by the system.

Applicability and use of the ecosystem

The PSSUQ questionnaire was sent to 41 healthcare professionals who used the system. The questionnaire was answered by 26 of the users. The mean score for general use of the system was considered good, with a value of 6.3 and a standard deviation (SD) of 0.7. The mean scores of the subscales detailed by group and the standard deviation are described in Table 1.

Table 1. System evaluation using the Post-Study System Usability Questionnaire scores.

		Mean	SD
General	Overall satisfaction	6,3	0,7
	System usefulness	6,3	0,9
	Information quality	6,2	0,7
	Interface quality	6,3	0,7

Veracity, authenticity and integrity of the data

The data authenticity and integrity process was performed via information sent by email together with the data exported, as seen in Figure 5. The process allows database authentication through the file exported or the authenticity link.

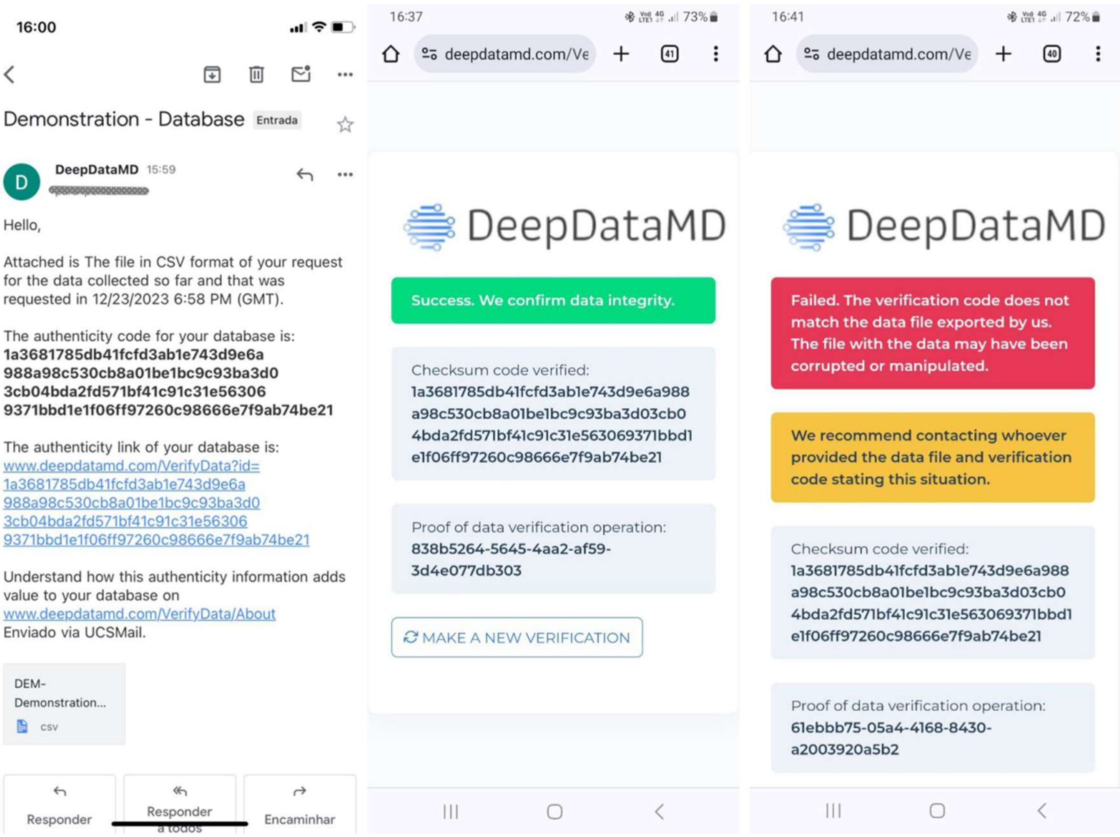

Figure 5 - E-mail with the authenticity codes and the exported database. The file received by email was verified, and a value was modified to illustrate the failed test.

DISCUSSION

The data ecosystem monitoring and management process is automated in a system accessed by a website. The ecosystem supports multiple databases, clinics, and points of care working simultaneously. The system also supports various research centers associated with the databases. This organization allows the same system to manage the data collection for multiple databases and medical records.

The use of conversation apps such as WhatsApp to interact with patients is documented and is a positive help in health activities [22,23]. The format utilized by healthcare professionals, in most cases, tends to be manual, interacting directly with the patient or multiple patients through groups in which texts and links are shared [24–26]. Automatic use through systems is also utilized and documented [27,28]. Automatic sending of messages is achieved by integrations and communications between systems and Application Programming Interface (APIs).

Pérez et al. [28] created algorithms to automate the exchange of messages by WhatsApp without performing the integration between databases and sending the messages, thus generating two distinct systems that are not connected. This study completely integrated the DHE system and other message apps. This integration format allows current and future questionnaires to be available in the database system and WhatsApp in real time. Lucena et al. [29] utilized a partially automated format. Besides the partially automated studies, there are works about the rate of response between different means of communication, and the results of these studies indicate a better rate of response to messages sent by WhatsApp than by e-mail. [30,31].

Integration and automation between systems make it easier for patients with motor and cognitive difficulties to access communication apps, promoted by assistive technologies such as voice assistants that enable access to apps with WhatsApp, Telegram, SMS, and e-mail [32]. The current study used audio messages that contained the text and the options of the questions as an alternative form to filling in the questionnaires. The messages in audio format were made available in the WhatsApp app automatically and simulating a conversation. Other studies have already used audio to collect questionnaires but not autonomously and directly in the WhatsApp app [33,34]. Using already known and used applications avoids the cost of understanding how they work and familiarizing yourself with new tools or even installing and configuring these applications [35].

The verification, integrity and authenticity of data and files by Hash codes and Checksum algorithms is widely employed in information technology (IT) [36]. These codes are generated from input content and can be generated as often as needed. Any change in the content will generate a new code and thus differ from the original [37]. Some studies in biology utilize the Hash code mechanism to validate attributes of an RNA sequence [21]. The authenticity codes check whether the data collected are valid and can be verified by third parties. Usually, the scientific articles mention in the methodology how and what software was used to collect the data. Hash code generation, together with verification forms, allows reviewers and third parties to confirm the data used in scientific papers. This mechanism would enable adding an extra layer of authenticity to the data since the authenticity codes and links would be available.

CONCLUSION

The new functionalities and mechanisms added to the system allowed multiple conversation channels to communicate autonomously with patients and healthcare professionals. The same system interlinked clinical practice with numerous databases and communication via Telehealth calls. The databases were integrated into WhatsApp, and the questionnaires were answered directly in the conversation app. The data collected were verified and authenticated.

REFERENCES

1. Hogervorst MA, Vreman RA, Mantel-Teeuwisse AK, Goettsch WG. Reported Challenges in Health Technology Assessment of Complex Health Technologies. Value in Health. 2022 Jun 1;25(6):992–1001.

2. Spertus J. Barriers to the Use of Patient-Reported Outcomes in Clinical Care. Circ Cardiovasc Qual Outcomes. 2014 Jan 1;7(1):2–4.

3. Falavigna A, Teles AR, Braga GL de, Barazzetti DO, Lazzaretti L, Tregnago AC. Instrumentos de avaliação clínica e funcional em cirurgia da coluna vertebral. Coluna/Columna. 2011;10(1):62–7.

4. Falavigna A, Righesso Neto O, Teles AR. Avaliação clínica e funcional no pré-operatório de doenças degenerativas da coluna vertebral. Coluna/Columna. 2009 Sep;8(3):245–53.

5. Santana MJ, Haverman L, Absolom K, Takeuchi E, Feeny D, Grootenhuis M, et al. Training clinicians in how to use patient-reported outcome measures in routine clinical practice. Quality of Life Research. 2015 Jul 15;24(7):1707–18.

6. Teles AR, Righesso O, Gullo MCR, Ghogawala Z, Falavigna A. Perspective of Value-Based Management of Spinal Disorders in Brazil. World Neurosurg. 2016 Mar 1;87:346–54.

7. Goeree R, He J, O'Reilly D, Tarride JE, Xie F, Lim M, et al. Transferability of health technology assessments and economic evaluations: a systematic review of approaches for assessment and application. Clinicoecon Outcomes Res. 2011;3:89–104.

8. Nelson EC, Eftimovska E, Lind C, Hager A, Wasson JH, Lindblad S. Patient reported outcome measures in practice. BMJ. 2015 Feb 10;350:g7818.

9. Pellizzoni L, e Silva S de A, Falavigna A. Multilanguage health record database focused on the active follow-up of patients and adaptable for patient-reported outcomes and clinical research design. Int J Med Inform. 2020 Mar 1;135.

10. Huf S, Kerrison RS, King D, Chadborn T, Richmond A, Cunningham D, et al. Behavioral economics informed message content in text message reminders to improve cervical screening participation: Two pragmatic randomized controlled trials. Prev Med (Baltim). 2020 Oct 1;139:106170.

11. Poblete P, Nieto E. Does time matter? WhatsApp vs electronic mail for dental education. A pilot study. European Journal of Dental Education. 2020 Feb 1;24(1):121–5.

12. Blasiak A, Sapanel Y, Leitman D, Ng WY, De Nicola R, Lee VV, et al. Omnichannel Communication to Boost Patient Engagement and Behavioral Change With Digital Health Interventions. J Med Internet Res [Internet]. 2022 Nov 1 [cited 2023 Apr 16];24(11). Available from: https://pubmed.ncbi.nlm.nih.gov/36383427/

13. Moreira A, Alves C, Machado J, Santos MF. An Overview of Omnichannel Interaction in Health Care Services. Mayo Clinic Proceedings: Digital Health [Internet]. 2023 Jun 1 [cited 2023 Apr 16];1(2):77–93. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2949761223000160

14. Vest JR, Grannis SJ, Haut DP, Halverson PK, Menachemi N. Using structured and unstructured data to identify patients' need for services that address the social determinants of health. Int J Med Inform. 2017 Nov 1;107:101–6.

15. Assale M, Dui LG, Cina A, Seveso A, Cabitza F. The Revival of the Notes Field: Leveraging the Unstructured Content in Electronic Health Records. Front Med (Lausanne). 2019 Apr 17;6:439247.

16. Ometov A, Bezzateev S, Mäkitalo N, Andreev S, Mikkonen T, Koucheryavy Y. Multi-Factor Authentication: A Survey. Cryptography 2018, Vol 2, Page 1. 2018 Jan 5;2(1):1.

17. Lewis JR, R. J. Sample sizes for usability tests. Interactions. 2006 Nov 1;13(6):29.

18. Turner CW, Lewis JR, Nielsen J. Determining Usability Test Sample Size. International Encyclopedia of Ergonomics and Human Factors. 2006;3:3084–8.

19. Lewis JR. Psychometric Evaluation of the PSSUQ Using Data from Five Years of Usability Studies. Int J Hum Comput Interact. 2002 Sep;14(3–4):463–88.

20. Parah SA, Kaw JA, Bellavista P, Loan NA, Bhat GM, Muhammad K, et al. Efficient Security and Authentication for Edge-Based Internet of Medical Things. IEEE Internet Things J. 2021 Nov 1;8(21):15652–62.

21. Love MI, Soneson C, Hickey PF, Johnson LK, Tessa Pierce N, Shepherd L, et al. Tximeta: Reference sequence checksums for provenance identification in RNA-seq. PLoS Comput Biol [Internet]. 2020 [cited 2023 Apr 26];16(2):e1007664. Available from: https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1007664

22. Al-Rayes SA, Alumran A, Aljabri D, Aljaffary A, Aldoukhi E, Alahmedalyousif Z, et al. Public Awareness and Utilization of 937-Telephone Health Services in the Kingdom of Saudi Arabia Before and During the COVID-19 Pandemic: Longitudinal Study. J Med Internet Res 2021;23(7):e27618 https://www.jmir.org/2021/7/e27618 [Internet]. 2021 Jul 30 [cited 2023 May 6];23(7):e27618. Available from: https://www.jmir.org/2021/7/e27618

23. Giordano V, Koch H, Godoy-Santos A, Belangero WD, Pires RES, Labronici P. WhatsApp Messenger as an Adjunctive Tool for Telemedicine: An Overview. Interact J Med Res 2017;6(2):e11 https://www.i-jmr.org/2017/2/e11 [Internet]. 2017 Jul 21 [cited 2023 May 6];6(2):e6214. Available from: https://www.i-jmr.org/2017/2/e11

24. Manji K, Hanefeld J, Vearey J, Walls H, De Gruchy T. Using WhatsApp messenger for health systems research: a scoping review of available literature. Health Policy Plan [Internet]. 2021 Jun 3 [cited 2023 May 6];36(5):774–89. Available from: https://academic.oup.com/heapol/article/36/5/774/6226979

25. Othman M, Menon V. Developing a nationwide spine care referral program on the WhatsApp messenger platform: The Oman experiment. Int J Med Inform [Internet]. 2019 Jun 1 [cited 2023 May 14];126:82–5. Available from: https://pubmed.ncbi.nlm.nih.gov/31029267/

26. Al-Atif HM. A Cross-Sectional Survey of Knowledge of Skin Cancer in Saudi Arabia. Dermatol Pract Concept [Internet]. 2021 Jul 1 [cited 2023 May 14];11(3). Available from: https://pubmed.ncbi.nlm.nih.gov/34123567/

27. Gesser-Edelsburg A, Shahbari NAE, Cohen R, Halavi AM, Hijazi R, Paz-Yaakobovitch G, et al. Differences in Perceptions of Health Information Between the Public and Health Care Professionals: Nonprobability Sampling Questionnaire Survey. J Med Internet Res 2019;21(7):e14105 https://www.jmir.org/2019/7/e14105 [Internet]. 2019 Jul 3 [cited 2023 May 6];21(7):e14105. Available from: https://www.jmir.org/2019/7/e14105

28. Pérez Zaballos MT, Ramos Macías, Pérez Placencia D, Borkoski Barreiro SA, Ramos de Miguel. LifeQuestionnaire. A new tool for the evaluation of quality of life in patients with hearing loss-using WhatsApp. Eur Ann Otorhinolaryngol Head Neck Dis. 2016 Jun 1;133:S44–9.

29. Lucena TFR, Negri LQ, Marcon D, Yamaguchi MU. Is WhatsApp Effective at Increasing the Return Rate of Blood Donors? Telemed J E Health [Internet]. 2020 Mar 1 [cited 2023 May 14];26(3):304–9. Available from: https://pubmed.ncbi.nlm.nih.gov/30925120/

30. Saxena K, Gunjal S. Influence of WhatsApp and electronic mail reminders on oral hygiene compliance of orthodontic patients using planimetry : A randomized clinical trial. J Orofac Orthop [Internet]. 2022 Jul 1 [cited 2023 May 14];83(4):269–76. Available from: https://pubmed.ncbi.nlm.nih.gov/33944974/

31. Poblete P, Nieto E. Does time matter? WhatsApp vs electronic mail for dental education. A pilot study. Eur J Dent Educ [Internet]. 2020 Feb 1 [cited 2023 May 14];24(1):121–5. Available from: https://pubmed.ncbi.nlm.nih.gov/31631472/

32. Velasco-álvarez F, Fernández-Rodríguez Á, Vizcaíno-Martín FJ, Díaz-Estrella A, Ron-Angevin R. Brain-Computer Interface (BCI) Control of a Virtual Assistant in a Smartphone to Manage Messaging Applications. Sensors (Basel) [Internet]. 2021 Jun 1 [cited 2023 May 14];21(11). Available from: https://pubmed.ncbi.nlm.nih.gov/34073602/

33. Perlis TE, Des Jarlais DC, Friedman SR, Arasteh K, Turner CF. Audio-computerized self-interviewing versus face-to-face interviewing for research data collection at drug abuse treatment programs. Addiction [Internet]. 2004 Jul 1 [cited 2023 May 14];99(7):885–96. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/j.1360-0443.2004.00740.x

34. Morrison-Beedy D, Carey MP, Tu X. Accuracy of audio computer-assisted self-interviewing (ACASI) and self-administered questionnaires for the assessment of sexual behavior. AIDS Behav [Internet]. 2006 Sep 23 [cited 2023 May 14];10(5):541–52. Available from: https://link.springer.com/article/10.1007/s10461-006-9081-y

35. Coleman E, O'Connor E. The role of WhatsApp® in medical education; A scoping review and instructional design model. BMC Med Educ [Internet]. 2019 Jul 25 [cited 2023 May 14];19(1):1–13. Available from: https://link.springer.com/articles/10.1186/s12909-019-1706-8

36. Brown BJ. Checksum methodology as a configuration management tool. Journal of Systems and Software. 1987 Jun 1;7(2):141–3.

37. Hamming RW. Error Detecting and Error Correcting Codes. Bell System Technical Journal. 1950;29(2):147–60.

APÊNDICE B – ARTIGO II

Exploration of flexible pricing models in the software architecture of a medical system

Leonardo Pellizzoni; Alexandre Erasmo Krohn Nascimento; Scheila de Avila e Silva; Asdrubal Falavigna

ABSTRACT

This article examines the pricing models for medical software and the availability possibilities for healthcare professionals. Research was performed in databases to find pricing models and how to include them in the software. This work also explores cloud computing options such as Software as a Service (SaaS). The results show the little-explored pricing field, especially regarding long-term use, considering maintenance and changes in software and pricing models. The present paper proposes an organization of the pricing models in software architecture aiming at changing prices and business requirements.

KEYWORDS

Software-as-a-Service; Pricing models; Software Architecture; Business Models; Literature Review

1 INTRODUCTION

This study analyzes the research on knowledge bases to explore articles that utilize the Software as a Service (SaaS) model in commercial applications. There is a problem with pricing software developed to collect information directly from patients and physicians. The target consumers are healthcare professionals who must collect data using questionnaires that patients can answer directly without medical intervention. The software is currently undergoing tests, validations and adjustments [1].

The software combines concepts of Health Technology Assessment (HTA), Patient-Reported Outcomes (PRO) and constant exploration of the information collected. HTA enables the comparison of different clinical treatments in various areas of medicine, promoting the efficient use of available resources [2]. An effective way to obtain this data set is by using questionnaires such as the PRO, which allow data collection directly from the patients without intermediaries [3]. The information collected from questionnaires is essential for the decision-making process, allowing the metrics to measure the efficacy, accuracy, and effectiveness of healthcare professionals and the patient's quality of life [4,5].

Patients are committed to answering the questionnaires when they perceive the information's usefulness for better understanding and treatment [6]. A few barriers limit the use of the PRO, such as time restrictions, lack of help to collect data, long duration of the questionnaires, and the absence of a dedicated database [7]. Although systems have been developed to improve the follow-up and evaluation of clinical treatments [8], it is necessary to adopt flexible systems to customize the questionnaires according to the specific population and clinical practices [9].

The developed ecosystem is hosted and available through the Azure public cloud, supplied by Microsoft [1]. Cloud computing allows users to employ various services and computer configurations, eliminating the need to install or maintain servers locally and the cost-benefit ratio, in which users only pay for what they utilize [10].

The reason for choosing the SaaS format was the capacity to significantly reduce the costs of Information Technology (IT) and promote a flexible business. A common characteristic of SaaS business services is that the client's data are stored and processed by the service provider, in this case, Microsoft [11]. Using the SaaS model, it is possible to concentrate on building and maintaining the ecosystem because the Microsoft company is responsible for the servers' maintenance, updating, configurations and availability.

Considering the scientific benefits of HTA and the difficulties encountered in employing the questionnaires and other measurement instruments, the objective of the software developed is to automate the process of collecting information for clinical analysis. However, there is a gap in the billing model of the software when making the system available for use by the health professionals' community.

2 THEORETICAL REFERENCE

One of the difficulties encountered by the new digital businesses is monetization. This difficulty can be observed in apps and popular sites such as YouTube, Instagram, WhatsApp, and Facebook [12]. These platforms initially did not have a clear pricing model and were not immediately profitable. WhatsApp does not charge a fee for most users. The Meta Group that owns WhatsApp performs the monetization per messages sent by utilizing the WhatsApp API (Application Programming Interface) [13].

Other apps and software monetize by means of announcements (ads) or purchases within the platform, but to generate significant income through ads, it is necessary to have a high volume of viewings and utilization. The next sections discuss some of the pricing formats appropriate to the model of SaaS and explain the functioning and modalities of availability of software in the cloud.

2.1 Cloud computing

Cloud computing is considered an evolution of traditional servers because it allows the utilization of minimal resources at the beginning and gradually increases according to the users' demands. The resource increase is instantaneous, enabling a flexible adaptation to the required computing need. Cloud computing offers several advantages: absence or easy installation, configuration, updating, compatibility, computing power and reduced costs [14–16].

The cloud computer services are offered as three main modalities: 1) Infrastructure-as-a-Service (IaaS): the user contracts for virtual machines (VM) and is responsible for managing the computer resources; 2) Platform-as-a-Service (PaaS): the user obtains a pre-configured environment to make their own product available [10] and 3) Software-as-a-Service (SaaS): the user contracts a specific software and pays only for what is utilized.

These three formats available in cloud computing are explained from two perspectives: first, the possibilities offered to the contracting party and second, the ready and defined services available by the cloud companies, such as Microsoft, Google and Amazon.

Cloud computing presents a hierarchical order of the modalities, with IaaS at the base of the hierarchy, which offers greater control of the installation, configuration and utilization of the resources. PaaS stays at an intermediate level, where it is not necessary to configure servers at the infrastructure level but rather to focus on developing the software itself.

2.1.1 Infrastructure as a Service (IaaS)

Infrastructure as a Service (IaaS) is the lowest-level modality of service offered by cloud computing servers. In this model, the contractor assumes a high level of configuration and maintenance and is responsible for specifying some of the hardware configurations, updating operational systems, software and implementing security measures. It is necessary to have a team dedicated exclusively to the maintenance of the servers now hosted outside the company facilities. The hardware configurations include allocating specific computer resources to a server, such as 32 GB memory, Windows 11, and a 16-core processor. In addition, regarding paid programs, as in the case of Windows 11, the license and associated costs are the contractor's responsibility [16–18].

This modality of cloud service allows the allocating of computer resources by virtual machines located at the data centers of cloud computing providers. This results in a significant reduction of the capital costs associated with the acquisition and maintenance of new computers. The users can adjust the configurations and virtual machines according to their needs and pay only for the time they use them. In this context, utilization is measured by maintaining the virtual machine switched on [19].

2.1.2 Platform as a Service (PaaS)

A technological solution does not always require hosting in a dedicated Server to remain available to the end users. The software developed may sometimes be hosted in a server area called Platform as a Service (PaaS) [16,18].

One of the main advantages of the PaaS is its flexibility, in which the management and configuration are performed in a way optimized for system functioning, avoiding the unnecessary allocation of resources. Furthermore, PaaS offers quickly available libraries, databases, and other components needed for the system to operate without the need to install them. It suffices to inform the version desired and the specific needs. This way, the platform supplies the entire ecosystem configuration system needed. In addition, PaaS reduces the costs and complexity of system installation and maintenance [16,18].

The providers of this modality offer a broad environment for developing, testing, implementing, maintenance, and system management. The PaaS is widely utilized to make online sales systems available, offering an efficient solution to create and manage electronic commerce platforms [15].

2.1.3 Software as a Service (SaaS)

This modality provides greater availability of a site or system that can be accessed through computer navigators, cell phones or tablets, without worrying about servers, infrastructure and libraries [16].

The utilization of SaaS in cloud computing prevents the contracting party from worrying about contracting, acquiring, maintaining and software or hardware updating. These responsibilities are up to the cloud computer provider. The provider's IT team performs all the work of maintaining the software and hardware. Although this modality offers fewer configuration options for the end user, it is ideal because it transfers to the provider the costs and expenses of personnel who promote the maintenance of the server and software [17].

2.2 Pricing models

2.2.1 Traditional software license

This software monetization model purchases licenses of the software. In the traditional model, the software owner establishes a price and the user pays for the license, acquiring the right to permanently use that specific software version. The end user may utilize the software but does not have permission to modify or resell it. This model is known as the End User License Agreement and is popular for games and software traditionally delivered and acquired on CDs/DVDs, where an activation key (Product Key) was supplied to activate the product [20].

The initial acquisition cost tends to be high and involves purchasing the product as any other consumer good. However, the model may not ensure updates and permissions to utilize new software versions, and thus, the user may be left with an obsolete product. As a result, the user needs to acquire a new license to allow access to the most recent version of the software [21]

2.2.2 Subscription

Unlike purchasing licenses, the end user agrees to pay a subscription to guarantee continuous access to the system. This type of business model is commonly utilized for internet-based systems. One of the advantages of this model is that the initial cost is lower, just for the software license. Furthermore, the continuous updating and addition of new functionalities become a way to retain the users. In the subscription model, the software supplier needs to provide a level of support to the user and the hardware and software maintenance. Music, film and series services are common examples of this billing model [22].

2.2.3 Ads

The business model based on ads on sites and other systems is characterized by the free use offer, in which the users are exposed to publicity while employing the service. These ads may be related to the user's activities or be shown en masse. The revenue from this business model is based on the number of visualizations and revenue from clicks on the ads [23].

2.2.4 Freemium

The Freemium modality offers two distinct business models. There may be a free version of the software with limited resources and a version usually paid for by subscription, which offers all complete functionalities to the end users. The free version aims to serve as a point of entry for the product, allowing new users to use it without initial cost. This free approach tends to attract new users who begin their journey in software. If they perceive its usefulness and return, these users are more likely to disseminate news about the product. For this modality to work, it is essential that the revenue generated by the paid version be able to sustain the costs of the free version. This relationship does not need to be necessarily proportional, but it is important that the revenue from paid users make it possible to offer the free version to other users.

Besides, it is crucial to consider that if the paid services are unsatisfactory or do not meet the users' needs, they will probably continue using the free version [24].

3 METHOD

The discussion on pricing products offered as SaaS generally covers three main topics: 1) estimate of costs related to hosting and utilization of services; 2) determine the techniques to find the ideal configuration of the servers at the lowest cost possible; and 3) definition of the pricing model for a product hosted in a cloud computing infrastructure. Studies discuss the projection of costs in the cloud for a given configuration of use, but this is not the focus of the present article, especially considering that providers such as Microsoft Azure already offer cost projections [25,26,27]. The central issue is how to bill the end users for using a system and the services hosted in the SaaS modality. The system is hosted continuously and the billing occurs even if no clients use it. On the other hand, a single hosting can potentially serve many or all end clients who access the system.

This study aims to review the literature from 2010 to 2022 and discuss the pricing of products offered as SaaS. For this purpose, research was conducted in the ACM DL[3], IEEE Explore[4] and ScienceDirect[5] bases. We started the review in 2010, when Microsoft Azure was launched that year.

The database search resulted in 108 papers filtered by each article's abstract. Filtering by abstract eliminated 66 articles, resulting in 42 articles for the research. A second filter was carried out by the methodology and objectives of each article, which eliminated 37 papers and left five articles for analysis. The five articles related to the research problem were analyzed and their results are presented in the Results section. The articles are listed in Table 1.

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3 https://dl.acm.org/action/doSearch?fillQuickSearch=false&target=advanced&expand=dl&field1=Abstract&text1=price&field2=Abstract&text2=saas&AfterMonth=2&AfterYear=2010&BeforeMonth=12&BeforeYear=2022

4 https://ieeexplore.ieee.org/search/searchresult.jsp?action=search&newsearch=true&matchBoolean=true&queryText=(%22Abstract%22:price)%20AND%20(%22Abstract%22:saas)&ranges=2010_2022_Year

5 https://www.sciencedirect.com/search?tak=saas%20price&date=2010-2022

Table 2. Selection of the articles utilized to elaborate the results and research of the questions discussed in this paper

Work	Authors	Ref.	Year
Cloud Pricing Models: A Survey and Position Paper	Gohad et al	[20]	2013
SaaS architecture and pricing models	Laatikainen et al	[28]	2014
Selection of the Proper Revenue and Pricing Model for SaaS	Ojala	[21]	2015
Adjusting software revenue and pricing strategies in the era of cloud computing	Ojala	[29]	2016
Do We Know How to Price SaaS: A Multi-vocal Literature Review	Saltan	[30]	2019

4 RESULTS

Developers must adapt to the changes and new paradigms, such as cloud computing, to remain competitive in the software market and businesses. It is necessary to rethink how the products are offered to the clients since the traditional licensing and software development contracts are becoming stricter and more demanding. In this context, the transition to a model based on cloud servers offers a more convenient solution, substituting the practice of licensing software individually for each client [29,31].

Due to the intangible nature of the software products, the initial prices tend to be high, while the reproduction and delivery costs are generally lower or even close to zero. This allows the software developers to adopt models with varied revenue and prices. The license may impose restrictions on the use of the software, such as a prohibition to resell, modify or rent the software without permission [32,33]. The traditional model of software license sale involves selling a license permanently to a single user or machine or selling a license that allows using the software in a given number of processors. [34].

Ojala (Ojala, 2016) applied the theory of competitive advantage proposed by Porter (1997) to approach the following question: How can SaaS providers adjust their revenue and price strategies in competitive markets? The main question was then deployed into two secondary questions: (1) What competitive forces motivate the SaaS providers to adopt the software rental model? And (2) What competitive forces prevent the SaaS providers from adopting the software rental model?

Adequate pricing schemes and techniques are essential to developing and maintaining a sustainable cloud ecosystem [35]. The rental or licensing can be defined as a contractual agreement allowing the temporary use of an object without conferring on the user all possible future use rights. In a rental contract, the client does not acquire full ownership of the rented object.

Some studies indicate that the shorter the expected usage time of a good, the greater the benefits of transactional costs (i.e. rent) rather than immediate purchase [36]. The reasons why a client may choose to rent software instead of purchasing it are as follows: (i) the software is to be used for a short-term project, (ii) the client wishes to obtain experience in using the software, (iii) the client wishes to test and evaluate the usability of the software, or (iv) the client wishes to avoid negative externalities of the network [32].

The software rental model in the SaaS format also reduces the clients‘ need to have their own IT and IT infrastructure teams. This diminishes the cost of ownership and reduces the hidden costs that may increase IT expenditures by up to 80% in the case of licensing traditional software [37].

Businesses have favored software rental as the first option for several reasons: (i) diminished development costs, (ii) expansion of the client base, (iii) differentiation of the competitors and (iv) price flexibility. The rental model via the cloud reduces the costs associated with the installation, delivery, implementation, maintenance and post-sales support. The businesses can supply updates that are immediately visible to all clients. Those who may not have a budget for the initial investments required by traditional software licensing are encouraged to adopt the cloud model. In this way, the software rental transfers the client's capital investment to the operational costs, enabling smaller businesses to begin using the software without needing a special budget or approval from higher management [29].

In some cases, certain clients may be so important that the software firms are prepared to offer their product through a license. The reasons why the clients prefer a license may be related to (i) concerns with security, (ii) resistance or low acceptance of new technologies, and (iii) existing IT infrastructure available [29].

Besides the choice of the revenue model, choosing a model with adequate pricing is not always a simple decision between binary models, as stated by other studies [38,39]. Actually, the choice of the most appropriate price model will depend on the competitive forces present in the market. Software providers tend to use fixed price models more, such as based on the number of users [29,40]. This contradicts the assumption that the delivery based on a cloud depends on use [41–43]. None of the businesses analyzed by Ojala (Ojala, 2016) mentioned the reduction of the transaction costs associated with software rental, which is different from the previous studies discussed [32,44]. The results found in the study of Ojala [29] indicate that the software rental model reduces development costs and makes software rental lucrative and attractive for both the supplier and the client. The software rental also helped diversify the client base, making software products available to smaller clients.

The Saltan study [30] emphasizes the existence of a broad spectrum of words and terms related to the interaction between SaaS and pricing, making it difficult to adopt a standardized route to define prices and for comparative results. As regards the analysis of the factors that affect and compose the prices of SaaS, over half of the studies do not explicitly specify what factors have an effect and should be considered when designing and implementing a strategy for the pricing of SaaS. Often, these factors are derived from model assumptions comparing criteria or conclusions based on case studies.

The transition to the SaaS business model provides new opportunities for software companies regarding software development, delivery and operation [30,45]. These opportunities have implications for pricing, allowing the creation and expansion of price design and experimentation and monitoring and control mechanisms enabled by the recurrent subscription fees. Furthermore, new mechanisms arise to ensure efficient price discrimination and the tracking of real-time use.

The analysis performed by Saltan [30] reveals that most academic papers utilize mathematical and analytic modeling approaches to assess price strategies and mechanisms under different market conditions and product characteristics. However, the results indicate that the professionals in this sector are unfamiliar with or do not acknowledge the importance of academic research in SaaS product prices. This lack of consistency limits obtaining broad knowledge regarding SaaS product pricing. To design effective price strategies and tactics, it is necessary to be acquainted with other fields, such as sociology, psychology, decision theory, and other social sciences [30].

Interestingly, researchers identified a gap in the academic literature regarding explicitly discussing the design of SaaS product prices, including creating prices, destination pages, sales funnel structures and market segmentation. In the context of supplying software such as SaaS, this approach potentiates the opportunities for software developers and third parties to create specific products for the market, such as plug-ins, extensions and new resources for their main products [20].

As indicated by Ojala [21], some studies indicate that adopting the SaaS model is more closely related to the strategic benefits than the direct economic benefits for the companies. As to price assessment, the pricing models in SaaS can be categorized as use-dependent prices, prices based on the users, or a combination of both. In the use-dependent pricing model, the fee is determined based on the volume of transactions, memory requirements, or other parameters related to software use. On the other hand, in the user-based pricing model, the clients pay a fixed rate to enjoy unlimited use of the software. As emphasized, the low costs associated with the SaaS model could potentially drive the client base growth [21].

According to Ojala (2015), the analysis of the cases revealed a wide variety of software price models available in both revenue models. The businesses can utilize them individually or in a combined form. Similarly to the licensing options, the software rental enables the adoption of prices that can be individualized based on the number of users, functionalities utilized and other requirements. The nature of lower initial costs in renting software allows expanding the client base, including small and medium-sized businesses, previously limited to large clients. Furthermore, the rental model makes it possible to offer the software at an accessible price to clients who need it only for a short period of use in response to their specific needs. [21].

Additional results also emphasize how the SaaS providers can be motivated to offer their products under license to essential clients, especially due to concerns about data security, but mainly when these clients already have an established infrastructure available. Generally, these companies are medium to large-sized. The software companies favor the rental model since it offers flexible prices and lower production costs. Renting the software also allows the companies to protect their businesses against the possibility of a supplier change and allows easier access to smaller clients who cannot pay the high initial costs associated with the traditional licensing model [21].

The results obtained by Laatikainen [28] emphasize the close relationship between the software architecture and the prices in the cases in which the company’s proposal of a value depends on or is available at a high level of maturity in the cloud and outsourced providers, such as Amazon Microsoft or Google perform the hosting. Modeling the architecture of the software allows customizing the prices, formats and plans or versions of the products offered. Consequently, a flexible and well-designed software architecture enables the adoption of different price models, while a badly designed architecture limits the pricing options. The decisions related to the prices should be informed with sufficient advance in the software development life cycle since the pricing models may generate new software requirements, such as scalability, high customization, and use of resources from public cloud providers.

Cases of changes in the pricing models should be emphasized that may be necessary for additional components such as a different infrastructure, automatic invoicing systems, or tools for configuration. Consequently, the pricing model also impacts the prioritization of the work to develop software. A relevant factor to be considered is the utilization of resources in the cloud that affect the price model, and during migration to a new environment, the prices may be lowered, and the pricing model may become simpler. Furthermore, price components may be introduced based on the use of the resources in the cloud [28].

According to the possibilities of pricing and considering the continuous change in the software over time to adapt to needs, this study opted to propose an organization of the pricing models in layers.

4.1 PROPOSAL FOR THE USE OF PRICING MODELS

The stakeholders supplied information about models, pricing, and the system's business rules. A defined pricing model could be validated as a business rule. In their simplest form, these rules can be defined as a part of the system that specifies its basic functionalities and how it operates. These information items are a major system asset and add additional value to the ecosystem over the long term if appropriately organized in the software structure [46,47]. A few basic principles should guide the implementation of business rules, such as: (i) they should be explicit, from a single source, and easily manageable; (ii) they can exist independently from procedures, workflows, and technologies. (iii) they should present a high level of decoupling. Decoupling is a fundamental resource because it divides the software into parts, layers or modules that allow diminishing the impact of changes and improvements [48].

One of the ways to implement business rules is through design patterns such as Services, Domains or architecture in layers [49]. Several styles and methods of software architecture exist, such as pipelines and filters, systems in layers based on events, implicit invocation, and specific software architectures in a domain. Software architectures based on layers are composed of different levels, specified as layers, each one dedicated to a specific part of the system. From the point of view of the system life cycle, layer architecture promotes the creation and evolution of parts of the system in an independent and reusable form. The use of these techniques adds strategic elements to the development of software, minimizing costs, potentiating reuse and increasing the amount of functionality of the system over time [50–52].

The layers usually utilized in software architecture are presentation, domain and model. The domain layer maintains the commercial rules relevant to the system, which are expressed in the source code and tend to remain stable for longer than the technologies used to accept them [53,54]. Therefore, the tendency is that the higher the degree of decoupling and interoperability, the greater the added/aggregated value to the system, enabling the incorporation of new technologies and the reuse of the business rules in future systems. [55].

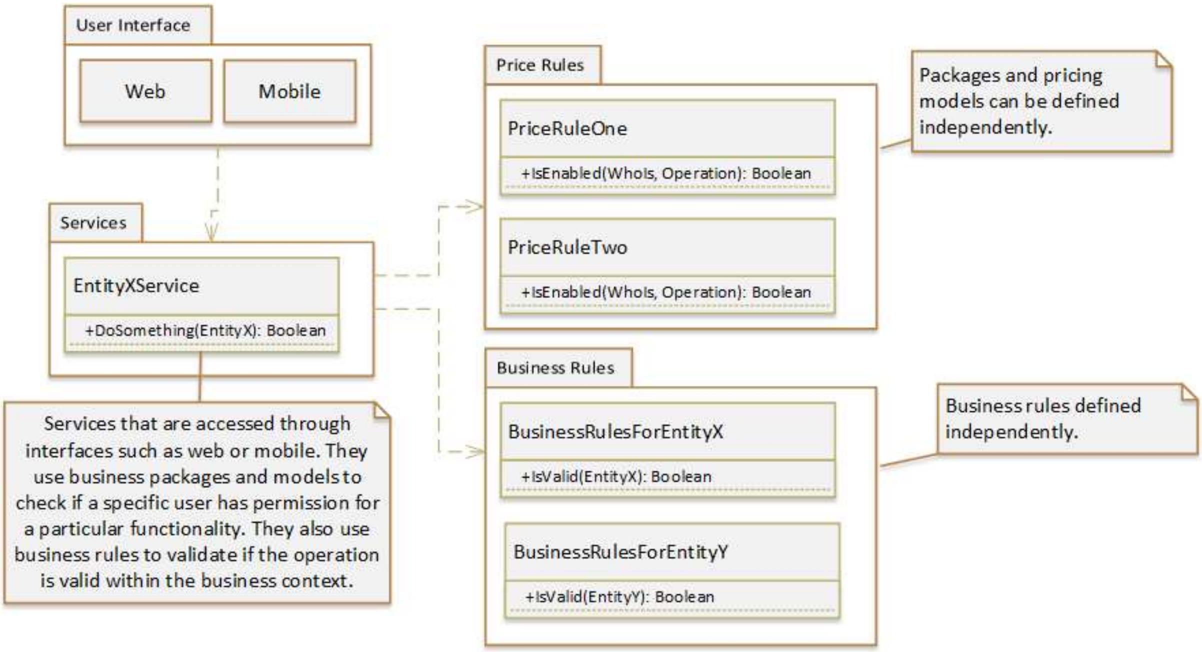

Figure 6 Organization of the business rules and pricing packages in the structure of the system

Based on these trends and the need for pricing models, it is proposed that the packages or pricing rules be handled similarly to the system's business rules. A possible organization for that is defined in Figure 1, where it is observed that the price rules and business rules were created in an isolated form, helping access through various layers of the software. The organization shown in Figure 1 utilizes the pattern of services as a form of access to the user interface layers with business rules and pricing models. In the scenarios where the user does not have a given functionality, the software through the service layer accesses the pricing model which performs the validation and can generate an exception and not allow the flow to continue. The same occurs for the business rules that follow the same principle. Through the exceptions the software performs a treatment of errors and shows the messages to the user in a user-friendly manner, informing how they can proceed or contract another plan that has support for a given functionality.

Isolation in specific layers using low coupling concepts for the pricing models and business rules also enables them to be utilized in other layers as tests and reutilized in future systems.

5 DISCUSSION

The studies analyzed in this work show a clearer division between approaches that analyze the cost of the cloud separately and those that consider it a factor to be incorporated into a product's business and pricing model. Generally, the cost of the cloud is not paid directly by the end user, especially because this user can share the resources of the cloud with other people without being aware of this. A notable example is Gmail or Google Drive, in which the data centers are shared by several persons who access them. This approach allows for diluting the cost between users. This study aimed to find methods, techniques or results that could help develop a product's pricing strategy. Although no specific formula to be applied was found, the results obtained offer a route to the pricing strategy based on the competitive forces, as evidenced in the work of Ojala (Ojala, 2016).

This study presents two limitations. The first concerns the size of the sample of companies analyzed by the papers, which was relatively small, with only five companies taken into account. Despite this limitation, the study significantly emphasizes the importance of software architectures as a crucial competitive factor in product pricing. The second limitation involves the costs of the cloud, especially in emerging countries, where the devaluation of the local currency in relation to the US dollar may impact the costs for companies that depend on foreign providers. It is important to consider these currency exchange factors when developing pricing strategies. However, using Porter’s competitive forces may be valuable to guide the choice of a company's business model and revenue that offers software, allowing a broader analysis of the competitive environment.

The dependence on the utilization of the cloud may generate a certain complexity since the resources need to be available even when the end user is not utilizing the system. This implies that the resources allocated are constantly in use from the standpoint of the cloud provider. An alternative would be to allow the user to configure and maintain their own environment in the cloud, but this would eliminate the advantage of reducing the complexity offered by the SaaS model. In this case, the end user would have to manage his own servers in the cloud, similar to the traditional model of the data centers, which would require constant maintenance and adjustments. However, this does not make it unfeasible for smaller users to utilize SaaS. This matter was discussed in most of the studies that seek to find an ideal p ricing point in the cloud provider context.

Software architecture is essential to organize a system, involving its components, interactions and the context in which it is inserted, besides the principles that guide its design and evolution [56]. The results of Laatikainen et al. [28] emphasize the importance of adequate planning and a solid organization of the systems in their architecture. This approach enables exploring and using additional market advantages in the future, besides contributing to the efficiency and quality of the software developed. A well-designed architecture allows greater flexibility, scalability and adaptability, preparing the system to deal more effectively with challenges and future demands. Thus, investing in planning and organizing software architecture is essential to maximize the market's benefits and opportunities.

The costs of transactions related to training and support are essential elements, independent of the model chosen, be it cloud or local, to ensure end users' good development of the systems. However, it is important to consider the influence of certain factors on the results obtained. One of these factors is related to purchasing power and parity between currencies. It should be considered that cloud providers generally charge in US dollars, which may result in higher costs for emerging countries, whose currencies are usually devalued in relation to the dollar. Furthermore, in some cases, small businesses and startups may operate with basic cloud services, which means the lack of customized configurations in the initial ranges of SaaS. On the other hand, in IaaS environments, businesses can configure their own cloud environment to host the software. However, this configuration requires time and additional resources from the companies. Therefore, it is essential to carefully assess these factors, considering the specific needs of the company to decide between the cloud or local models.

6 CONCLUSION

This paper proposes an organization of pricing models in software architecture, with a view to constantly changing these packages to suit user demand and the evolution of the software. The literature review identified that a product's pricing models are as important to the architecture and software as the business rules and other technologies that allow the system to work. Pricing models and their changes over time are often overlooked when building systems, making it difficult to include, create, use and migrate over time.

REFERENCES

1. Pellizzoni L, e Silva S de A, Falavigna A. Multilanguage health record database focused on the active follow-up of patients and adaptable for patient-reported outcomes and clinical research design. Int J Med Inform. 1º de março de 2020;135.

2. Ministério da Saúde. Secretaria de Ciência T e IEstratégicosD de C e T. Avaliação de Tecnologias em Saúde: institucionalização das ações no Ministério da Saúde. Rev Saude Publica. agosto de 2006;40(4):743–7.

3. Spertus J. Barriers to the Use of Patient-Reported Outcomes in Clinical Care. Circ Cardiovasc Qual Outcomes. 1º de janeiro de 2014;7(1):2–4.

4. Falavigna A, Teles AR, Braga GL de, Barazzetti DO, Lazzaretti L, Tregnago AC. Instrumentos de avaliação clínica e funcional em cirurgia da coluna vertebral. Coluna/Columna. 2011;10(1):62–7.

5. Falavigna A, Righesso Neto O, Teles AR. Avaliação clínica e funcional no pré-operatório de doenças degenerativas da coluna vertebral. Coluna/Columna. setembro de 2009;8(3):245–53.

6. Santana MJ, Haverman L, Absolom K, Takeuchi E, Feeny D, Grootenhuis M, et al. Training clinicians in how to use patient-reported outcome measures in routine clinical practice. Quality of Life Research. 15 de julho de 2015;24(7):1707–18.

7. Teles AR, Righesso O, Gullo MCR, Ghogawala Z, Falavigna A. Perspective of Value-Based Management of Spinal Disorders in Brazil. World Neurosurg. 1º de março de 2016;87:346–54.

8. Goeree R, He J, O'Reilly D, Tarride JE, Xie F, Lim M, et al. Transferability of health technology assessments and economic evaluations: a systematic review of approaches for assessment and application. Clinicoecon Outcomes Res. 2011;3:89–104.

9. Nelson EC, Eftimovska E, Lind C, Hager A, Wasson JH, Lindblad S. Patient reported outcome measures in practice. BMJ. 10 de fevereiro de 2015;350:g7818.

10. Murthy MKM, Sanjay HA, Ashwini JP. Pricing models and pricing schemes of IaaS providers: A comparison study. ACM International Conference Proceeding Series. 2012;143–7.

11. Tsai WT, Sun X, Balasooriya J. Service-oriented cloud computing architecture. ITNG2010 - 7th International Conference on Information Technology: New Generations. 2010;684–9.

12. The Top Downloaded Apps in 2022 [Internet]. [citado 13 de agosto de 2022]. Disponível em: https://www.visualcapitalist.com/top-downloaded-apps-2022/

13. Plataforma do WhatsApp Business [Internet]. [citado 13 de agosto de 2022]. Disponível em: https://developers.facebook.com/docs/whatsapp

14. Mell P, Grance T. The NIST Definition of Cloud Computing Recommendations of the National Institute of Standards and Technology. 2011;

15. Zhang Q, Cheng L, Boutaba R. Cloud computing: State-of-the-art and research challenges. Journal of Internet Services and Applications. 20 de maio de 2010;1(1):7–18.

16. António Miguel Ferreira. Introdução ao Cloud Computing. IaaS, PaaS, SaaS, Tecnologia, Conceito e Modelos de Negócio. FCA; 2015.

17. Chavan P, Patil P, Kulkarni G, Sutar R, Belsare S. IaaS cloud security. Proceedings - 2013 International Conference on Machine Intelligence Research and Advancement, ICMIRA 2013. 8 de outubro de 2014;549–53.

18. Sarkar MK, Kumar S. A framework to ensure data storage security in cloud computing. 2016 IEEE 7th Annual Ubiquitous Computing, Electronics and Mobile Communication Conference, UEMCON 2016. 7 de dezembro de 2016;

19. Sotomayor B, Montero RS, Llorente IM, Foster I. Virtual infrastructure management in private and hybrid clouds. IEEE Internet Comput. 2009;13(5):14–22.

20. Gohad A, Narendra NC, Ramachandran P. Cloud pricing models: A survey and position paper. 2013 IEEE International Conference on Cloud Computing in Emerging Markets, CCEM 2013. 2013;

21. Ojala A. Selection of the proper revenue and pricing model for SaaS. Proceedings of the International Conference on Cloud Computing Technology and Science, CloudCom. 9 de fevereiro de 2015;2015-February(February):863–8.

22. Service Subscription Service Business. 4 de fevereiro de 2009;

23. Leontiadis I, Efstratiou C, Picone M, Mascolo C. Don't kill my ads! Balancing privacy in an ad-supported mobile application market. HotMobile 2012 - 13th Workshop on Mobile Computing Systems and Applications. 2012;

24. Pujol N. Freemium: Attributes of an Emerging Business Model. SSRN Electronic Journal [Internet]. 1º de dezembro de 2010 [citado 13 de agosto de 2022]; Disponível em: https://papers.ssrn.com/abstract=1718663

25. Valerio V Di, Cardellini V, Presti F Lo. Optimal pricing and service provisioning strategies in cloud systems: A stackelberg game approach. IEEE International Conference on Cloud Computing, CLOUD. 2013;115–22.

26. Ardagna D, Panicucci B, Passacantando M. Generalized nash equilibria for the service provisioning problem in cloud systems. IEEE Trans Serv Comput. outubro de 2013;6(4):429–42.

27. Pricing Calculator | Microsoft Azure [Internet]. [citado 6 de julho de 2022]. Disponível em: https://azure.microsoft.com/en-us/pricing/calculator/

28. Laatikainen G, Ojala A. SaaS architecture and pricing models. Proceedings - 2014 IEEE International Conference on Services Computing, SCC 2014. 17 de outubro de 2014;597–604.

29. Ojala A. Adjusting software revenue and pricing strategies in the era of cloud computing. Journal of Systems and Software. 1º de dezembro de 2016;122:40–51.

30. Saltan A. Do we know how to price SaaS: A multi-vocal literature review. IWSiB 2019 - Proceedings of the 2nd ACM SIGSOFT International Workshop on Software-Intensive Business: Start-ups, Platforms, and Ecosystems, co-located with ESEC/FSE 2019. 26 de agosto de 2019;7–12.

31. Barnett NJ, Parry G, Saad M, Newnes LB, Goh YM. Servitization: Is a Paradigm Shift in the Business Model and Service Enterprise Required? Strategic Change. 1º de maio de 2013;22(3–4):145–56.

32. Choudhary V, Tomak K, Chaturvedi A. Economic Benefits of Renting Software. http://dx.doi.org/101207/s15327744joce0804_2. 2009;8(4):277–305.

33. Sun W, Zhang X, Guo CJ, Sun P, Su H. Software as a service: Configuration and customization perspectives. Proceedings - 2008 IEEE Congress on Services, SERVICES 2008. 2008;PART2:18–24.

34. Ferrante D. Software licensing models: What's out there? IT Prof. novembro de 2006;8(6):24–9.

35. Li Z, Zhang H, O'Brien L, Jiang S, Zhou Y, Kihl M, et al. Spot pricing in the Cloud ecosystem: A comparative investigation. Journal of Systems and Software. 1º de abril de 2016;114:1–19.

36. FLATH D. THE ECONOMICS OF SHORT-TERM LEASING. Econ Inq. 1º de abril de 1980;18(2):247–59.

37. Waters B. Software as a service: A look at the customer benefits. Journal of Digital Asset Management 2005 1:1. 1º de janeiro de 2005;1(1):32–9.

38. Sundararajan A. Nonlinear Pricing of Information Goods. http://dx.doi.org/101287/mnsc10400291. 1º de dezembro de 2004;50(12):1660–73.

39. Susarla A, Barua A, Whinston A. A Transaction Cost Perspective of the "Software as a Service" Business Model. http://dx.doi.org/102753/MIS0742-1222260209. 1º de setembro de 2014;26(2):205–40.

40. Lehmann S, Buxmann P. Pricing Strategies of Software Vendors. Business & Information Systems Engineering 2009 1:6. 22 de outubro de 2009;1(6):452–62.

41. Armbrust M, Fox A, Griffith R, Joseph AD, Katz R, Konwinski A, et al. A view of cloud computing. Commun ACM. 1º de abril de 2010;53(4):50–8.

42. Dikaiakos MD, Katsaros D, Mehra P, Pallis G, Vakali A. Cloud computing: Distributed internet computing for IT and scientific research. IEEE Internet Comput. 2009;13(5):10–1.

43. Louridas P. Up in the air: Moving your applications to the cloud. IEEE Softw. julho de 2010;27(4):6–11.

44. Varian HR. Buying, Sharing and Renting Information Goods. J Ind Econ. 1º de dezembro de 2000;48(4):473–88.

45. Dutt A, Jain H, Kumar S. Providing Software as a Service: a design decision(s) model. Information Systems and e-Business Management 2017 16:2 [Internet]. 19 de junho de 2017 [citado 14 de agosto de 2022];16(2):327–56. Disponível em: https://link.springer.com/article/10.1007/s10257-017-0356-9

46. Inmon WH, O'Neil BK, Fryman Lowell. Business metadata : capturing enterprise knowledge. Elsevier/Morgan Kaufmann; 2008. 292 p.

47. Ross RG. IT systems perspective - The business rule approach. Computer (Long Beach Calif) [Internet]. maio de 2003 [citado 19 de janeiro de 2018];36(5):85–7. Disponível em: http://ieeexplore.ieee.org/document/1198239/

48. Zhao K, Ying S, Zhang L, Hu L. Achieving business process and business rules integration using SPL. Em: 2010 International Conference on Future Information Technology and Management Engineering [Internet]. IEEE; 2010 [citado 20 de abril de 2018]. p. 329–32. Disponível em: http://ieeexplore.ieee.org/document/5656297/

49. Hamza HS, Fayad ME. A novel approach for managing and reusing business rules in business architectures. Em: The 3rd ACS/IEEE International Conference on Computer Systems and Applications, 2005 [Internet]. IEEE; 2005 [citado 7 de outubro de 2017]. p. 973–8. Disponível em: http://ieeexplore.ieee.org/document/1387165/

50. Sharma A, Kumar M, Agarwal S. A Complete Survey on Software Architectural Styles and Patterns. Procedia Comput Sci [Internet]. 1º de janeiro de 2015 [citado 8 de abril de 2018];70:16–28. Disponível em: https://www.sciencedirect.com/science/article/pii/S187705091503183X

51. MacCormack A, Sturtevant DJ. Technical debt and system architecture: The impact of coupling on defect-related activity. Journal of Systems and Software [Internet]. 1º de outubro de 2016 [citado 7 de outubro de 2017];120:170–82. Disponível em: http://www.sciencedirect.com/science/article/pii/S0164121216300760

52. Ebad SA, Ahmed MA. Measuring stability of object-oriented software architectures. IET Software. 1º de junho de 2015;9(3):76–82.

53. Brooks. No Silver Bullet Essence and Accidents of Software Engineering. Computer (Long Beach Calif) [Internet]. abril de 1987 [citado 7 de outubro de 2017];20(4):10–9. Disponível em: http://ieeexplore.ieee.org/document/1663532/

54. Garlan D, Barnes JM, Schmerl B, Celiku O. Evolution styles: Foundations and tool support for software architecture evolution. Em: 2009 Joint Working IEEE/IFIP Conference on Software Architecture & European Conference on Software Architecture [Internet]. IEEE; 2009 [citado 8 de janeiro de 2018]. p. 131–40. Disponível em: http://ieeexplore.ieee.org/document/5290799/

55. Haile N, Altmann J. Evaluating investments in portability and interoperability between software service platforms. Future Generation Computer Systems [Internet]. 1º de janeiro de 2018 [citado 8 de janeiro de 2018];78:224–41. Disponível em: https://www.sciencedirect.com/science/article/pii/S0167739X17307719

56. International Organization For Standardization. ISO/IEC 42010:2007 Systems and software engineering - Recommended practice for architectural description of software-intensive systems. ISOIEC 42010 IEEE Std 14712000 First edition 20070715. [publisher not identified]; 2007. p. 23.

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Responder a: Journal of Systems Architecture <support@elsevier.com>
Para: Leonardo Pellizzoni <lpellizzoni@ucs.br>

CC: "Alexandre E Krohn Nascimento" aeknasci@ucs.br, "Scheila Avila e Silva" sasilva6@ucs.br, "Asdrubal Falavigna" afalavig@ucs.br

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Journal of Systems Architecture

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