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PAPER

Factors That Influence the Adoption of Digital Dental Technologies and Dental Informatics in Dental Practice

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ABSTRACT

The factors affecting information systems and technology have become a growing topic in many disciplines. This study focuses on factors affecting the adoption of digital dental technologies and dental informatics in dental practice. There are limited studies in the literature on factors that affect the adoption of digital dental technologies (DDT) and dental informatics (DI). Understanding the factors is important for the success of the adoption of technologies. Therefore, this study aims to fill that gap. This paper reviews peer-reviewed literature to analyze factors that affect the adoption of digital dental technologies (DDT) and dental informatics (DI) and critically examines an array of technology acceptance models to unveil the underlying determinants of DDT and DI adoption. Usability and practical considerations, work efficiency factors, socioeconomic and organizational aspects, aspects of the learning curve, and system design are the most important factors influencing the adoption of digital dental technologies and dental informatics. The study results identified the conceptual framework for the factors affecting the adoption of digital dentistry.

KEYWORDS

dental informatics (DI), digital dental technologies (DDT), electronic health record (EHR), computer-aided design and manufacturing (CAD/CAM), cone-beam computed tomography (CBCT)

1 INTRODUCTION

The saying above depicts that everything, desired or otherwise, will, in due course, assimilate into society. Adoption is the process of changing in a gradual, ongoing, and incremental manner in response to external factors [1]. Scholars and practitioners have always been eager to assess the technological side of change and its impact on organizations [2]. The organizational process of altering a firm to use new technology is called technological adoption.

The hypothesis put forward by Rogers (1962) [3] in the early 1970s is as follows: "Potential adopters want to know the degree to which a new idea is better than

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an existing one." Several distinct theories have been applied by various authors to explain the concept of adopting technology and innovation. Technology adoption denotes a stage in the process at which a decision is made to adopt a technology. This particular stage incorporates several activities, such as decisions made by managerial, professional, or technical staff based on both the internal and external settings of an organization. Hameed et al. (2012) [4] delineated that adopting new technologies and innovative practices in an organization can be sparked in one of the following two ways: (1) as a reaction to a shift in the external setting, or (2) through the incorporation of innovative practices that will be required at some point in the future as part of their daily operations.

1.1 Factors in adoption models

Some theories, including the Theory of Reasoned Action (TRA), the Theory of Planned Behavior (TPB), and the Diffusion of Innovation (DOI) Theory, have been used to explain the reasons for people to adopt new technologies. These theories account for the inevitable progress of technological advancement [5]. Several acceptance theories and their central constructs are listed in Table 1 for better comprehension and to build the conceptual framework.

Table 1. The individual acceptance theory and its fundamental constructs

Individual Acceptance Theory	Description	Core Constructs
Theory of Reasoned Action (TRA)	As the initial theory of human behavior, the TRA has been used in many studies related to individual acceptability of technology.	Attitude Individual norm
Technology Acceptance Model (TAM)	TAM is used to forecast the acceptability of and intention to employ IT on the work.	Usefulness Ease of use Individual norm
Motivational Model (MM)	Psychology-based evidence for behavior-motivational hypothesis.	Extrinsic Motivation Intrinsic Motivation
Theory of Planned Behavior (TPB)	Expansion of the TRA to embed the concept of behavioral control to better understand factors that affect intention and behavior.	Attitude Individual norm Behavioral Management
Combined TAM and TPB (C-TAM-TPB)	TAM and TPB are combined in this model to create a hybrid model of perceived utility.	Attitude Individual norm Behavioral Management Usefulness
Model of PC Utilization (MPCU)	As opposed to the TRA and TPB, this model forecasts individual usage and not the intention.	Complexity Long-term effect Social contributors Favorable circumstances
Innovation Diffusion Theory (IDT)	This sociologically grounded model is used to explore new forms of organizational technology.	Proximity Agreement Willingness
Social Cognitive Theory (SCT)	One of the most influential theories of human behavior is to assess productivity and IT competence.	Anxiety Self-Esteem Performance

Users' emotions and how they perceive others to feel about task execution are explained in TRA, one of the earliest theories for doing so [6]. The Technology Acceptance Model (TAM) measures one's confidence in the efficacy of a given method to enhance performance [7]. The Motivational Model (MM) indicates that an activity is performed to gain a reward (monetary, social, or other) [8]. The TPB is an extension of the TRA that embeds one's opinion of how difficult an activity is. The Combined TAM and TPB (C-TAM-TPB) refers to a hybrid model that determines one's perspective, self-regulation, and practicality. As for the Model of PC Utilization (MPCU), it looks at how much faith one has in using complex technologies. To comprehend why a new development is thought to be superior to its forerunner in line with established norms, the Innovation Diffusion Theory (IDT) is sought. Meanwhile, the Social Cognitive Theory (SCT) evaluates the impact of one's actions on the productivity, reputation, and quality of his or her decisions.

In guaranteeing security and enhancing the quality of treatment, the healthcare business serves as a crucial support system for modern society. Radical transformations drive the healthcare reformation, and this includes the adoption of new technologies. For instance, HIS is a factor in the internal environment that prioritizes quality and offers practical tools that support positive outcomes. The significance of HIS in a hospital to ensure the delivery of high-quality care must not be underestimated. Some conditions, such as social normative hurdles, networking, professional or individual authority, medical expertise, knowledge, and scientific evidence, are critical for disseminating medical innovations. Imminently, HIS records the latest information promptly to enable accurate medical decision-making.

This section describes the essential function of management for the adoption of technology in the dental sector and, subsequently, the importance of individual behavioral intention. According to Sutton et al. (2020) [9], it is integral for hospital staff to possess strong communication and project planning skills so that they can implement information systems and IT services effectively. Service employees can better evaluate the organizational and technological settings after adopting advanced technologies. However, the user-friendliness and convenience of deploying a new technology should be taken into consideration by the management. Hence, the hospital administration should determine the pace of technological change to establish a baseline against which future improvements in medical care can be measured

2 FACTORS THAT INFLUENCE THE ADOPTION OF DIGITAL DENTAL TECHNOLOGY AND DENTAL INFORMATICS

2.1 Usability and practical considerations

Information quality is a crucial aspect of successful technology adoption [10]. In clinical settings, accurate information dissemination by IT systems is a significant benefit. This is discussed in the digital image analysis subsection, which highlights the importance for dentists to gain assistance when making quick but accurate decisions. Technology innovations in decision-making avoid issues brought on by human-worker differences. Any advanced IT system can diagnose the same issue indefinitely without growing weary, bored, or irate. Algorithm judgments are typically unbiased and uninfluenced by doctors, patients, or the entire dental team [11]. The consistency and accuracy of information are crucial aspects of technology adoption in dental health care because, in a clinical setting, misdiagnosis and malpractice may result in costly compensations and legal actions [12, 13].

At times, new technologies inevitably place constraints on their applicability and pose a barrier to the widespread adoption of technological solutions. A study by Acharya et al. (2017) [14] investigated the use of IT by general dentists in the US. Prior to the turn of the century, some usability issues that arose with the implementation of computers in dental clinical usage were commonly related to technology use, such as dependability, space, speed, and user interface. They added that it was reasonable to assume that the progression of technology as a whole could have influenced the elements that they had outlined to some extent. Ease of use is one of the three key elements that determine technology adoption in the original TAM, which is applicable in the clinical context as well [15]. Other usability factors have been established in the context of dentistry. The following discusses several other key aspects, such as standardization, system integration, data privacy, patient safety, and readiness to embrace technologies.

Given that the most advanced information systems in diagnostics demand very standardized scenarios prior to application, it is difficult to generate such standardized circumstances by using the fuzzy process [16]. A digital image analysis program, for example, can only handle images of a standard size and resolution, including images in which the patient is positioned in a standard manner. The new capabilities of digital technology, utilizing 3D facial scans, have acceptable levels of reliability for soft tissue analysis. However, additional investigations are required to validate these findings. The development of radiation-free techniques has the potential to become a more reliable approach, aiming to minimize the exposure of orthodontic patients to radiation. The lack of standardization for comparison and diagnosis hinders the adoption of 3D images. Therefore, conventional radiological methods, such as CBCT, are still utilized even in non-elective cases due to their defined requirements. The study suggests that the integration of intraoral scanning with 3D facial scans has the potential to emerge as the preferred diagnostic method in the field of orthodontics.

Nonetheless, the complex human body and variances among patients are hindrances to technology. Patients with strong abnormalities in the region of interest present a very tough issue. As new technology is used, the treatment process almost always needs to be rethought to be simplified and organized more linearly. Although redesigning the procedures is challenging and demands more time, the result is a workflow that is more efficient and transparent. Low variation in the process due to standardization generates more accurate conclusions about the therapy.

In the unified theory of acceptance and use of technology (UTAUT) model, the integration of the related factors turns into a problem if more software programs are implemented [17]. Besides, poor data standards may plague a system if the technologies deployed in oral healthcare are not used for very long. Integration issues have been a concern, especially those that arise between various countries and providers. Data privacy must be addressed in dental healthcare, similar to other information systems. Data stored in dental information systems, which is an attribute of the healthcare sector, contains sensitive data about patients.

The use of new information systems requires the assurance of the safety of both patients and dentists. Controlling infections and ensuring the sterility of the equipment being used are essential prerequisites for using new technologies in medical settings. According to Ahadzadeh et al. (2015) [18], some operators have expressed concerns that using computers during a visit would increase the likelihood of contracting an illness. The radiation doses must be managed and maintained as low as possible during digital radiology analysis. Data acquisition becomes difficult because radiation doses must be controlled.

As stipulated by Carayon et al. (2019) and Safi et al. (2018) [19, 20], a huge barrier to the use of new technologies in healthcare settings is the absence of data that indicates productivity and quality improvement. Many dental professionals require more information before investing in advanced health technologies. Some dentists claimed that these new technologies were never truly ready and should be deployed sooner so that their functions could evolve in the following years to gain a market edge.

2.2 Work efficiency factors

Work efficiency derived from adopting dental information systems is a vital outcome, which is similar to the performance expectation found in the UTAUT model. Since work occurs at a rapid pace in dental clinics, information systems are critical as they swiftly deliver the data sought by the personnel for the efficient execution of their duties [21]. For instance, the CEREC technology substantially reduces the time required for designing and producing implants, thus enhancing treatment time.

An obstacle that derives from new technologies is the potential for disruptions in the process. System failure, sluggish response time, an intricate user interface, and other factors may cause interruptions in service provision. A slower workflow leads to additional challenges, such as cost inefficiency and inconvenience felt by patients due to lengthy appointment periods [22, 23]. For instance, a digital radiology image from eight years ago might have improved the decision-making process, but additional steps are required to address the malfunctions [24].

Although the use of information systems is meant to even out the differences in levels of ability and competence that exist among dentists, some personnel may delegate more difficult responsibilities to others in the team. For instance, several important procedures in the treatment, such as the analysis of images, the planning of treatment, and the selection of appropriate materials for the job, demand the skill of a seasoned dentist. It is now possible for dental hygienists and nurses to carry out their tasks efficiently because of the proliferation of information systems. While the rest of the team is responsible for such tasks, the dentist is free to focus on his or her work with the patient. This work process is efficient, and the dentist can communicate effectively with the patient because he or she is not required to spend time on the supportive analytical tasks. Simply put, the implementation of a new IT system would turn out to be unsuccessful if the system increased the workload of a dentist [25].

2.3 Socioeconomic and organizational aspects

Social influence is a significant component of IT acceptability in the model proposed by Beldad and Hegner (2017) [26], while Veerankutty et al. (2018) [27] highlighted the importance of individual and organizational impacts in the context of adopting new technologies. Apart from the technological challenges, some social variables have been proven to affect the adoption of IT in therapeutic settings. Individual preferences, dentist-patient relationships, cooperation among dental team members, and organizational variables are some obstacles to the use of technology in the clinical context. According to Van der Zande et al. (2015) [28], the adoption curve for technology is applicable in the dental sector after weighing in several unique circumstances. Rogers classified the intended consumers of new technologies as innovators, early adopters, the early majority, and laggards based on their readiness to accept new technology [28]. Within the dentistry context, early adopters are often specialists instead of general dentists, as well as young dentists instead of senior dentists.

Individual preferences and resistance are commonly manifested as follows: clinical operators are accustomed to a great degree of independence in their job, and they respect their competence. This may result in the opposite when an information system is deployed as a supplementary component. Physicians may experience discomfort using technologies before their patients because they do not want to appear incompetent [29]. This archaic thinking style exists in a culture of great competence and autonomy. For instance, the introduction of blood pressure monitors in the early 20th century led many physicians to believe that it would pose a threat to their unique talent of monitoring blood pressure without any gadgets. To date, machines are everywhere.

Macpherson et al. (2021) [30] reported that some professionals felt that the IT systems had disrupted the dialogue between patients and dentists. A patient's view of technology may play a critical role in whether or not the patient chooses to employ it [31]. The perspectives of colleagues towards IT may influence whether the dental team is prepared to accept new technologies or not. Cutting-edge technologies may be perceived as innovative and influential or as a great hindrance to the status quo of roles and responsibilities within the team. Hence, organizational support and management attitude are significant variables that dictate technology adoption at the organizational level. For example, lacking training on new systems may eventually emerge as a major deterrent to technology usage by employees [28]. This reflects the UTAUT model's enabling circumstances that affect technology adoption, as IT support provided by a company has an impact on the spread of new tools in the healthcare setting [32].

Another organizational aspect that significantly affects technology adoption is cost. Spending on technology includes the costs of learning, purchasing, maintaining, and upgrading the systems. It is also crucial to consider the cost of failure. Rework and alternative methods during maintenance can increase expenses related to technology adoption [28]. Due to the intense competition in the dental healthcare industry, the adoption of new technologies should be viewed as an investment. Such investment might, however, be difficult for tiny, one- or two-room clinics within the private sector because they have less spare cash. Larger operators and chains can take risks with new technology because they have the capacity to absorb failing investments. Similarly, Van der Zande et al. (2015) [28] revealed that the usage of technology increased with the size of clinics in the Netherlands. While smaller and more specialized clinics are often the early adopters of the most specialized technology, larger clinics face bureaucracy and organizational constrictions, as well as slowly evolving information management.

2.4 Aspects of the learning curve

The extent of one's prior experience with IT has a direct bearing on the person's propensity to embrace new technologies for the medical sector [33]. Although the final products of new technologies should be intuitive and user-friendly, they necessitate the creation of new knowledge. Hence, suppliers commonly provide re-education for newly developed technologies, mainly because user training and support are crucial in the process of clinical technology adoption [34]. Courses on new technologies are costly, and dentists may be required to travel quite a bit to acquire the latest knowledge about novel technologies. The Nordic Institute of Dental Education (NIDE) in Finland is an example of a dental education establishment. The institute was established based on a partnership between Turku University and Planmeca Oy. The NIDE offers courses to students from across the globe on a variety of topical areas, such as CEREC technology and 3D imaging.

As education takes time, it inevitably cuts into the time that can be spent on clinical work. According to Gagnon et al. (2012) [35], time restrictions are the main obstacle to effective technology adoption. Time is wasted when a dentist is not yet entirely accustomed to the technology, and the risk of making mistakes is higher until the dentist is comfortable using the new technology [28]. Adopting new technologies is heavily influenced by the level of expertise in IT and the preparedness of the workforce to operate in a digital setting. Experienced dentists who have been performing manual labor and have never received any exposure to a digital setting may find it difficult to embrace new technology [28]. Zitzmann et al. (2020) [36] claimed that since the use of IT has been successfully embedded into dental education in recent years, newly-graduated dentists possess high-level preparedness to use information systems.

2.5 Perspective of vendors: System design

Jeyaraj (2020) [37] integrated the TAM and DeLone and Mclean's Model of Information System Success into the healthcare context. As a result, he discovered the following factors that were particularly imminent for the success of an information system: the availability of sufficient information, good interface design, and updated information on the system. Achieving success based on these variables makes the system's design the single most important component. While developing a new information system that can be used for diagnostics and patient work in a dental clinic environment, Noushi and Bedos (2020) [38] found that some principles should be adhered to. Designing an information system becomes impossible without first having an understanding of the workflow and how information is handled in an office setting. Moreover, it is crucial to comprehend the procedures that dentists adhere to before implementing any new piece of information technology. Developing information solutions for oral healthcare merely from a technical standpoint would eventually fail due to the extremely intricate working context.

Noushi and Bedos (2020) [38] highlighted the importance of user-centered design. They added that all technological solutions should be designed specifically to meet the needs of dental experts, and failing to do so would only create a chaotic and complex workflow. During the design phase of these new technologies, collaboration is imminent among technology designers, dental professionals, and vendors. The inclusion of end-users during the design process is vital to ensuring the success of clinical information systems [39]. Even the most sophisticated technologies could fail if a mismatch exists between the new technology and clinical working methods.

The information systems will fail in their application if the user interfaces are not well-designed, intuitive, and intricate. Dental personnel should not face any glitches navigating the site, locating crucial features and information with relatively little effort, and making use of one or, if feasible, as few sources of information as possible. The information systems should be easy to use, even with their complicated functionality. To maintain a continuous workflow without disruption, rapid reaction time is required.

2.6 Additional factors that influence the adoption of digital dental technology and dental informatics

Several factors that influence the usage of digital technology in the medical sector have been identified in many studies. Some of these factors are the connection with educational goals, the difficulty of balancing analog and digital technologies, academic curriculum design, the rapid obsolescence threat, faculty and staff training, technological infrastructure, and the safety of the system or tool [40]. Despite the cutting-edge developments, some challenges keep arising, such as professional underrepresentation and data security concerns, due to the widespread access to computers and high-speed internet connections [41]. If clinical practice lacks awareness pertaining to digital technology, mistakes may be made or technological acceptance may be sluggish [42]. The motivators for implementing digital dental technologies despite acceptance rely on one's area of expertise, age, certification period, and belief in the benefits offered by technology or whether it is merely a contemporary curse [43].

3 THE ADOPTION OF ELECTRONIC MEDICAL RECORDS IN THE WORLD

With the passing of the HITECH Act in 2009, the implementation of EMRs by healthcare facilities and providers has progressed through various stages [44]. After the HITECH Act was passed in 2009, 59% of hospitals and 48% of physicians had employed at least the basic EMR. This signifies increments up to 47% and 26%, respectively, over the past year. A comparative analysis showed that before the HITECH Act, only 12% of hospitals used EMR. By 2015, over 84% of the hospitals had implemented at least the basic EMR [45]. As a result, 54% of doctors used at least some form of EMR in 2015, compared to 17% in 2008 [45].

Since 2010, a substantial increment has been observed in the rate of EMR adoption, particularly among not-for-profit teaching hospitals established in metropolitan cities. A study that assessed the rate of EMR implementation discovered that between 2013 and 2014, the adoption rate of fundamental EMRs rose from 33.4% to 41.1%, while the adoption rate of comprehensive EMRs increased from 25.5% to 34.1% [46]. The adoption rate of EMRs for family physicians was 68.0% in 2011, which surpassed the rate for other office-based physicians [47].

The adoption rate for medical practices across rural regions in the US was greater than that noted in urban areas, as revealed in an analysis that examined the variations in the adoption rates of office-based physician practices in rural and urban areas. The adoption rates for EMRs in 2012 were 56% and 49% in rural and urban areas, respectively, indicating that the Regional Extension Centers' outreach initiatives had an impact on the adoption rates [48]. In 2013, 69% of doctors were expected to participate in the EMR incentive program, as highlighted in a study that examined their participation intentions and readiness to achieve meaningful usability objectives.

According to Hsiao and Hing (2014) [49], only 19% of the participants who intended to take part had EMRs that met meaningful usability goals, while 56% lacked those capabilities. The use of EMRs by office-based doctors grew by 21% between 2012 and 2013. In 2013, 48% of office-based physicians used basic EMRs, which revealed an increment in the use of EMRs from 48% in 2009 to 78% in 2013. However, the results showed that the adoption rates varied significantly across the states, ranging from 21% in New Jersey to 94% in Minnesota. Besides, the hospitals and providers exchanged clinical data effectively, which was one of their primary goals in implementing EMRs [16].

While assessing the nursing homes in New York State from 2011 to 2012, a study discovered that 18% of the nursing homes successfully integrated the EMR system, and most of the nursing homes participated in health information exchange [50]. Meanwhile, 30% of the nursing homes indicated partial implementation, while 11.4% of the homes disclosed no EMR deployment. A study that assessed the adoption of health information technology in critical-access hospitals located in rural areas found that 89% of the participants implemented either full or partial EMR [51]. Upon adopting EMRs, small and rural hospitals lagged behind larger hospitals. Despite the achievements and positive effects of EMR usage, some healthcare practitioners displayed conflicting perspectives and a general sense of discontent.

4 THEORIES AND MODELS OF THE ADOPTION OF INFORMATION SYSTEM INNOVATIONS

Scholars have established a variety of theories and conceptual frameworks to examine the elements that may influence the spread of cutting-edge technologies. The adoption theories operate at two levels: the individual and organizational levels. While the TAM, the TPB, and the UTAUT have been proven to be effective at the individual level, both the DOI and the technology-organization-environment (TOE) frameworks are viable at the organizational level.

4.1 Individual level

Technology Acceptance Model (TAM). Figure 1 shows the TAM, which is a methodical way to test and explain how users accept a wide range of new information systems or personal technologies [52]. Mathieson et al. (2001) [53] asserted that the TAM is beneficial for forecasting user intentions to deploy technologies. The primary objective of TAM is "to offer a platform for tracing the influence of external circumstances on internal beliefs, attitudes, and intentions [54]." According to Davis (1985) [55], TAM can be used to discover the features embedded in a system that the users find unsatisfactory and later take remedial action to remedy the detected faults. Simply put, TAM enables researchers to view a system through the eyes of its users.

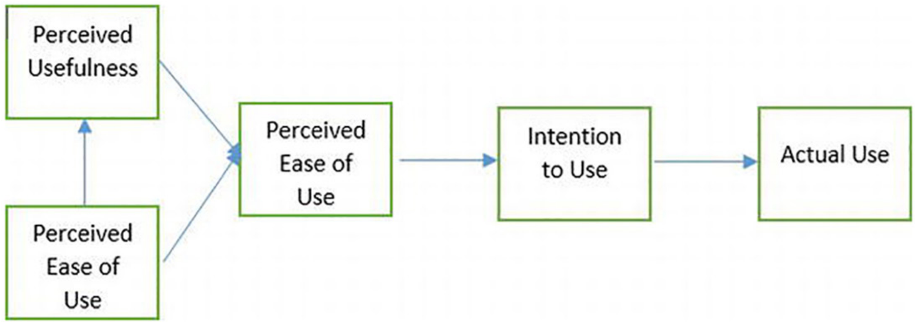

Fig. 1. Framework for the deployment of the TAM model [56]

Scholars frequently use the TAM model to gauge user acceptability of various technologies [57]. Although "substantial statistical results" have supported the "strong impact of perceived usefulness on behavioral intention to use a given system," Chuttur (2009) [58] asserted that there have been conflicting reports regarding the relationship between perceived ease of use and actual use. Because the initial TAM did not explain why a user believed the system to be beneficial or not, Venkatesh and Davis (2000) [59] expanded the TAM that Davis (1985) [55] had introduced.

Holden and Karsh (2010) [60] delineated that the TAM is an extendable model that can incorporate variables from other sources. Upon assessing the TAM empirically, Seed et al. (2010) [61] claimed that some investigations employed modified versions of the TAM instead of the original model. The TAM2 (see Figure 2) was introduced by Venkatesh and Davis [59] by expanding the perceived utility determinant of TAM to embed other components that offer granularity to the explanation of user intention [56]. Upon proposing TAM3, Venkatesh and Bala (2008) [62] included some elements related to the perceived ease of use and linkages, among other determinants. The task-technology fit model refers to an extension of the task analysis model developed by other researchers.

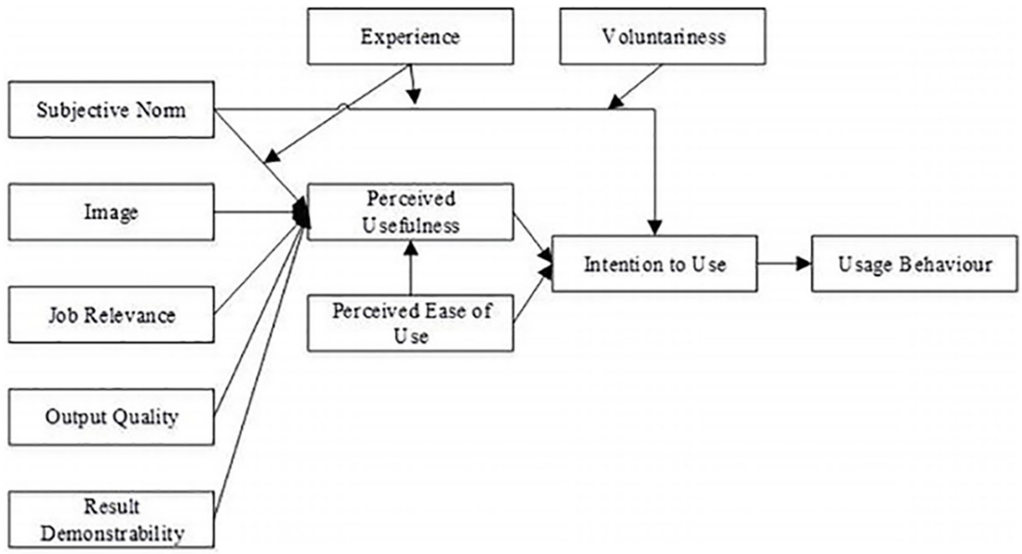

Fig. 2. Framework of the extended TAM model (TAM2) [56]

Theory of Planned Behavior (TPB). The TPB is one of the most significant theories often used to forecast behavior in relation to beliefs and behavior [63]. Although the TPB was not initially designed with the purpose of gauging how well people embrace new technologies, it looks into connections between attitude and conduct [64]. By measuring behavioral intention, the TPB assesses the end-perceived users' level of control over their actions [65]. Although this knowledge is helpful, it is incredibly limited when identifying factors that influence acceptance, as is the case with this present study.

Unified Theory of Acceptance and Use of Technology (UTAUT). In order to avoid complicating the TAM, Venkatesh et al. (2003) [66] integrated eight well-known models into a single, cohesive theory. Seven dimensions were selected as significant direct determinants of intention or usage based on an empirical analysis of the strongest predictors of technology adoption and use derived from the eight models. Only four of the seven dimensions were chosen as direct factors that can influence user acceptability and use, namely: performance expectancy, effort expectancy, social impact, and facilitating conditions. Meanwhile, self-efficacy and anxiety are fully mediated by either perceived ease of use (self-efficacy and anxiety [67]) or performance and effort expectancies, contradicting the theory that the three variables (attitude, anxiety, and self-efficacy) are indirect predictors of intention. Both self-efficacy and anxiety are significant factors that directly influence intention in the SCT research work. In-depth investigations revealed that this relevance only holds when control is absent to gauge effort expectancy.

Performance and effort anticipation are instances of attitudinal constructs. Self-efficacy, anxiety, and attitude are performance and effort expectancy constructs that are part of the UTAUT model. The UTAUT model disregards these three characteristics as direct factors that influence user acceptability and technology adoption. The UTAUT has four moderators that either enhance or hinder the overall impact of direct determinants on either intention or actual usage behavior. The four moderators are gender, age, experience, and voluntariness. Figure 3 illustrates the UTAUT model and the related relationships.

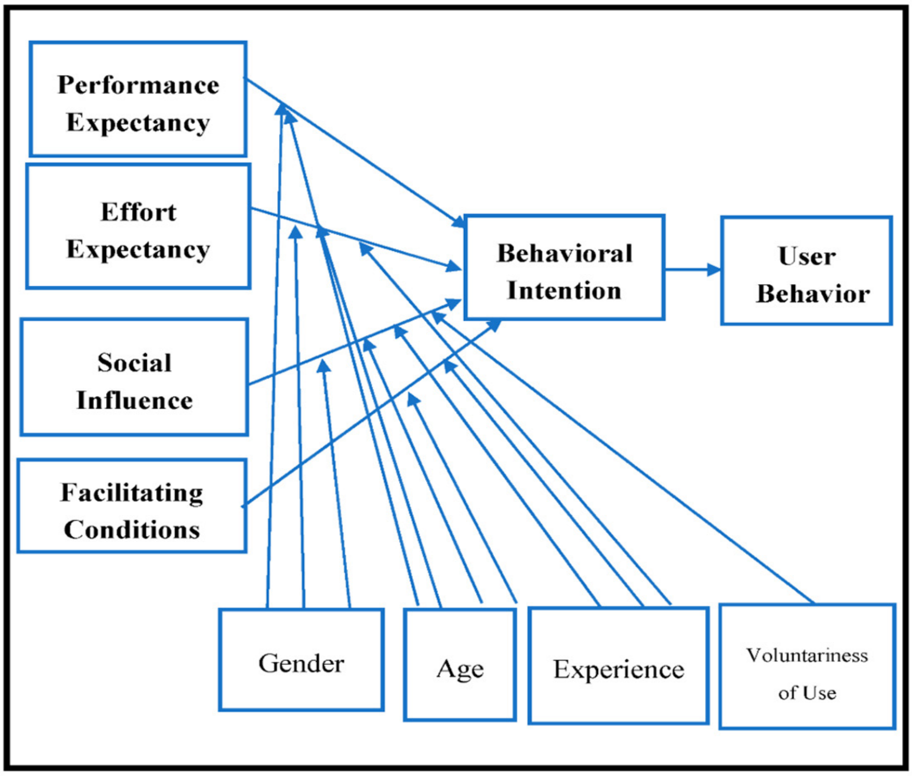

Fig. 3. Framework of the UTAUT model [68]

In order to ensure parsimony, only important predictors were selected from the eight models. Some core components of the individual models were excluded when UTAUT was developed. The authors highlighted the need for additional model revalidation or extension by emphasizing content validity and new measurements. Training was only stated in relation to technology acceptance and use in one of the two meta-analyses previously described as a factor buried within larger categories. The UTAUT can serve as a tool for managers to assess the likelihood of the adoption and usage of new technology [66]. The UTAUT model may be used to generate interventions, such as training and marketing, but this is only viable in a cursory manner and after the UTAUT is applied, instead of being a distinct component in the model. Turning to the present study, it will examine training reactions as a construct in the UTAUT model to accurately predict how well technology will be accepted and used.

Harris and Janz (2007) [69] mapped EHR to the UTAUT model and generated various hypotheses. Since the EMR mapping was based on an American physician, the outcomes reflected the American healthcare system, where money is prioritized. In this present study, the financial impact is taken care of by other health technology assessment components and projects a weak impact on healthcare personnel. This study highlights the misalignment of EMR processes with the existing workflow, which is a frequently discussed issue in EMR adoption. For instance, improper EMR usage may lead to user errors that exert an adverse impact on the patient's health [70, 71]. These obstacles can affect the usability and compatibility of technology in existing processes, which can affect the adoption and acceptance of technology among physicians. Given that training has an impact on doctors' workloads, they ought to use health information technology. Physicians from other generations perceive technology's usability differently. However, these are insignificant factors that can be generalized.

4.2 Organizational level

Diffusion of Innovation (DOI). The DOI theory, which Rogers introduced in 1962 [3], is one of the oldest and most frequently used social science adoption ideas in various fields [72]. The DOI theory depicts that adoption decisions are heavily influenced by the perceptions of adopters about the quality and benefits of innovation, which are more significant than the actual measurements of these attributes [73]. Both IT managers and top management are potential adopters when the traits of DOI theory are mapped to this study, while digital dental technology and informatics are the innovations.

Technology diffusion is a broad idea that covers a series of product lifecycle activities (programming, designing, development, implementation, testing, and hosting). It starts with research and development (R&D) and ends with product commercialization, which includes advertising, marketing, and promotion. When the diffusion process and the dynamics of technological development are better comprehended, more accurate and predictive models can be developed to enable rapid and accurate decision-making. As technological implementation results in several changes that influence society and long-term economic growth, input efficiency (e.g., labor and capital) increases to lower costs and boost profits.

The DOI theory explains how and why cultures are infused with new technology at individual and organizational levels, as well as how quickly this occurs [74, 75]. The four factors that influence diffusion practice in DOI theory are time, communication, social systems, and innovation [76]. The other six elements of the innovation component in DOI theory can affect the adoption of innovation [77, 78]. The six factors are compatibility, relative advantage, trialability, complexity, uncertainty, and observability, in that order. Technology adoption is positively influenced by these factors (except complexity and uncertainty).

Zhang et al. (2015) [79] examined factors that influenced patients' acceptance and use of consumer e-health innovations based on DOI theory. The 29-month longitudinal case study found that despite implementing the system for 29 months, the adoption and usage of the e-appointment service in a primary care clinic remained low. Some of the reasons include that the patients were not informed about the new e-appointment service, most patients felt that the new online service was inconvenient, the new service conflicted with the patients' preference for oral communication, and the service itself had several practical issues.

Referring to the DOI model, Cho et al. (2015) [80] evaluated the adoption behavior of a newly constructed EMR-based information system at three public hospitals in Korea. To examine the acceptance of the information system based on DOI theory, user satisfaction scores from four performance tiers were evaluated before and twice after the new system had been presented. The outcomes revealed that the doctors did approve of the new EMR system. Positive considerations were given by the physicians and nurses on how the new information system affected their clinical atmosphere.

At Partners HealthCare, an integrated delivery system with its headquarters located in eastern Massachusetts, the DOI theory was applied to examine the impressions of a patient portal among adopters and non-adopters [81]. A patient survey was performed to gather data from 372 respondents. The study demonstrated that if the patients believed a patient portal offered a comparative benefit over the current procedures, such as calling or going to the doctor's office, they were more likely to use the new technology. Companies seeking a rise in the use of patient portals may put measures in place to emphasize the relative benefits of portals, such as putting posters in waiting areas and examination rooms. As for age and wealth, a digital divide may be present in the use of patient portals.

The traits embedded in the DOI theory are (a) compatibility, (b) relative advantage, (c) trialability, (d) complexity, (e) uncertainty, and (f) observability. Since the studies we've talked about have used observability, complexity, and trialability as ways to measure willingness to accept technological advances, most past studies have shown that these criteria are less useful when it comes to adopting medical informatics in the healthcare sector.

Technology-Organization-Environment (TOE). The TOE framework is an adoption theory applicable at the organizational level [82]. The TOE framework (see Figure 4) offers a fresh stance on IT adoption because it considers technological, organizational, and environmental settings [82].

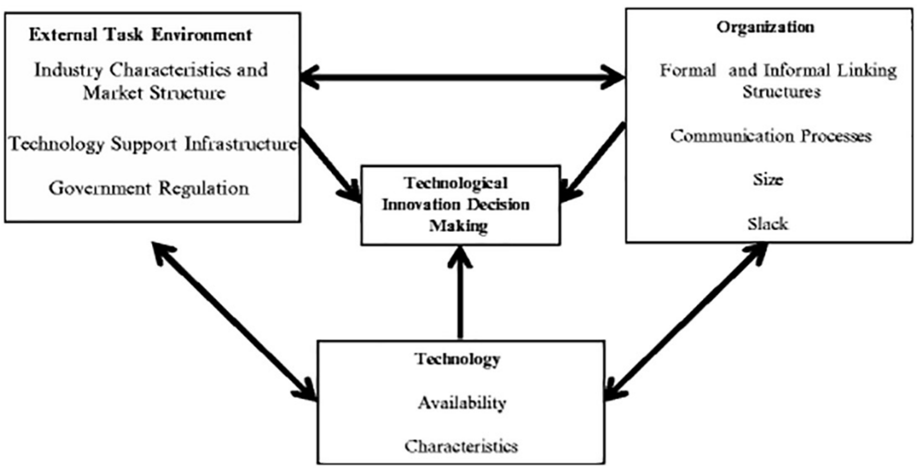

Fig. 4. Framework of the TOE [83]

The technical context emphasizes the ways in which the technological features may influence one's choice to embrace them. These characteristics are classified into the following criteria: (a) perceived benefits or relative advantages; (b) perceived obstacles; (c) compatibility; (d) perceived significance of compliance; (e) complexity; (f) trialability; (g) perceived hazards; and (h) perceived ease of practice [84]. The organizational facet concentrates on the fundamental elements that make up the organizational framework. These elements are company size, number of employees, and communication processes, which include the degree of centralization and formalization [85]. The organizational structure is a crucial determinant of the degree to which a given technology is adopted, besides affecting the degree to which employees of a company engage with one another socially. According to Oliveira et al. (2014) [74], organizations with a flatter or more decentralized structure make better use of contemporary technologies because they embrace new and intricate technology to enhance the coordination and communication processes within the company and externally with its partners.

The environment component focuses on the features of the industry, setbacks and possibilities, practices, and regulatory requirements that may influence the decision-making process involving the adoption of innovative technology [86, 87]. The decision-makers may be influenced by the external world, such as pressure from clients and competitors, thus causing them to react to their surroundings, imitate industry leaders, and follow conventional organizational norms [88]. Similarly, Almaiah et al. (2022) [12] and Khudzari et al. (2021) [89] asserted that external factors may influence the progress of technology adoption. The following paragraphs summarize recent studies that deployed the TOE framework.

A quantitative study based on the TOE theory was executed by Neamah, & Khanapi (2018) [90] to develop a model for Iraqi EMR adoption by assessing the impact of several exogenous factors. The study concluded that EMR adoption in Iraqi healthcare facilities was significantly influenced by knowledge and skill levels, training, attitude towards privacy and security, cost-efficiency, compatibility, complexity, support from top management, company size, IT capabilities, culture, policy, and government support. The effect of TOE factors on driving or impeding the decision to implement HIS was investigated by [91]. The study pioneered applying the DANP (Decision Making Trial and Evaluation Laboratory (DEMATEL)-based Analytic Network Processes (ANP)) approach to assess HIS adoption. Based on the opinions of experts who deployed DANP, the study demonstrated that perceived technical ability in the human dimension emerged as the most important component. In addition, compatibility and relative advantage played bigger roles in the technological component than the other factors. Top management support and financial resources appeared to be more significant than the other factors in the organizational dimension. Next, specialists in the environment dimension concurred that vendor support was the most important factor. Referring to professional advice, the study revealed that the administrators of hospitals should not dismiss the listed variables to ensure the effective implementation of HIS.

Based on the TOE theory, Yang et al. (2022) [92] explored the elements involved in the decisions made by integrated medical and healthcare facilities to adopt AI elderly care service resources. The study found that the adoption of AI healthcare service resources in medical institutions was affected by a lack of awareness of the value and benefits of AI, the high risk of data leakage, low management leadership support, and unsupportive government policies. Direct environmental variables that influenced the adoption decisions at the varied levels of healthcare facilities included competitive pressure, distrust among patients, and ineffective relationships.

To summarize, the TOE framework emphasizes internal organizational characteristics such as the level of support from top management, organizational scale, technological preparedness, and financial stability of the organization. The literature depicts that these factors are often relevant and favorably influence adoption decision-making.

5 DISCUSSION AND RESULTS

The factors have been divided into three main contexts: technological, organizational, and environmental. This categorization aids in the identification and analysis of significant concepts that developed from the literature review [93]. E-health strategies encounter several organizational obstacles, such as a lack of skilled healthcare professionals, insufficient health information systems, a shortage of resources, insufficient public information, and cost constraints [94]. The study on adoption in telemedicine found product design and patient relationship management to be the highest influences on adoption [95].

In studies that investigated the process of innovation adoption, the features of innovation have been extensively explored. The ability of an invention to be accepted by an individual, an organization, or an industry, along with the qualities and benefits of the innovation, better known as the technical features of the innovation, has a crucial role in the adoption decision. Therefore, the most important aspect in deciding to adopt digital dental technologies and informatics among dental practitioners refers to the technical aspects of the standards that are considered. In this present study, relative advantage, complexity, and compatibility were embedded into the proposed conceptual framework.

Roger (1995) [3] identified five perceived characteristics of an invention that can influence the rate of adoption of the innovation. The decision to adopt standards is made based on several factors, such as relative advantage, complexity, compatibility, trialability, and observability. These listed factors have been proven to be significant in influencing technology adoption. In addition, these factors may spawn new markets, goods, and services, which in turn offer a competitive advantage for early adopters.

The degree of relative advantage may be examined in economic terms, including speedier development, less maintenance, and better cost savings. The perceived relative benefit of the standard determines how quickly a technology will be adopted; a higher advantage leads to a faster adoption rate. The rising complexity of each standard increases the amount of effort necessary for implementation, thus reducing the possibility of adoption. Hence, the likelihood of a company adopting a standard decreases proportionally with the level of complexity it possesses. If the newly accepted standard is compatible with the existing technology and is consistent with the previous experiences of the company, the business will more likely upgrade to the new standard to gain a competitive advantage.

Technical considerations alone cannot fully explain many aspects of standard acceptance. Organizational variables have a significant impact on decision-making, although the adoption of digital dental technologies and informatics among dental practitioners can substantially enhance information sharing and connection within and across businesses. This stems from risks and uncertainties in adoption behavior due to prior experiences. Organizational culture, staff resistance to change, and organizational preparedness are all included in the proposed conceptual framework.

Organizations with a strong innovation culture are more inclined to try out new approaches to standards development. Businesses should build a learning organization to enhance their internal knowledge management methods, which allows one's expertise to mature into the collective expertise of the company. Companies with a deep understanding of standard adoption would eventually make better and timelier judgments. The efficacy of standard adoption is heavily influenced by a company's openness to sharing data with its trade partners. Early adopters of standards are more common in companies that encourage creativity, education, and open communication among employees.

Another barrier that hinders the deployment of digital dental technologies and informatics refers to the responses of employees, which typically stem from their lack of education pertaining to the relevance and benefits of HIS. Poor technical understanding causes employees to avoid change. The implementation of a medical computerized system can be a success or a disaster, depending on the employees' level of knowledge and expertise in IT.

Next, organizational readiness is imminent to implement innovation. Technology, resources, and organizational preparedness are critical to assessing the adoption of innovation. Organizational technology preparedness is closely linked with IT use and management competence. Managers offer top-level aid for associated technologies, IT professionals, and the professional knowledge, abilities, and experiences that are required for standard adoption. Resource readiness determines if a company can adapt to a technology. This factor is composed of financial resources for installation, improvements, and continuous usage, as well as human, material, and information resources. A company with high technology and resource readiness is more likely to embrace standards and make standard adoption decisions.

Since each organization operates in a certain society, it is subject to the impact of numerous external factors beyond its control. Since the environment is a force that either supports or hinders the adoption of HIS, environmental variables are significant and cannot be disregarded. In this present study, the proposed framework considers external pressure and network externality. Pressure from external sources, such as the government and the industry in which a company operates (i.e., business partners and/or competitors), and other sources (e.g., suppliers, clients, regulatory bodies, and professional associations), can influence the company to decide to adopt standards. In response to the impetus provided by these forces, a company may decide to embrace pertinent standards in an attempt to pursue sustainable development or actively improve its market competitiveness.

Network externalities are one of the two primary theories that are commonly used in the stream of an economic viewpoint on standards. This theory depicts the benefits yielded from adopting new standards by the community of prospective adopters. The widespread acceptance of a standard is catalyzed by the positive network externalities stemming from its implementation. The establishment of more contact among adopters leads to cost reduction. This is because economies of scale and synergies derive from these expanded opportunities. When more organizations in the community embrace the standard, barriers to adoption are reduced. Network externalities have a positive effect on organizations adopting standards. The conceptual framework displayed in Figure 5 serves as a guideline for this study.

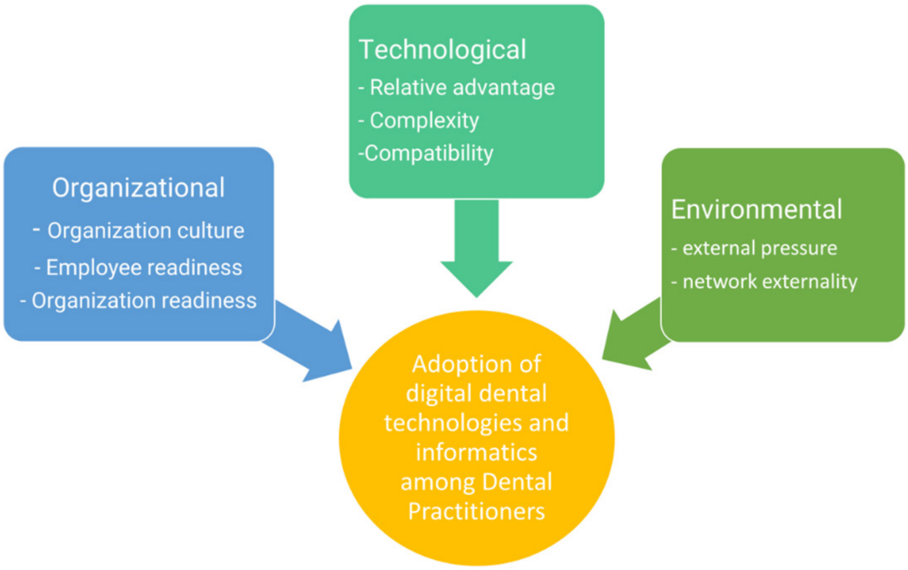

Fig. 5. Conceptual framework for the factors that influence the adoption of digital dentistry

6 CONCLUSION

This study has identified the most influential factors that influence the adoption of digital dental technologies and informatics in the literature review. Usability and practical considerations, work efficiency factors, socioeconomic and organizational aspects, aspects of the learning curve, and system design are the most important factors influencing the adoption of digital dental technologies and dental informatics. The study identified a conceptual framework for the factors that influence the adoption of digital dentistry.

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