

# Innovation in Ophthalmology and Dentistry Services: Benefits and Challenges of using AI

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**Abstract:** The development of Artificial Intelligence (AI) is revolutionizing different organizational contexts, including health services. Among these services, ophthalmology and dentistry stand out for being areas with intense use of technological innovations, mainly for obtaining images. The use of AI promotes innovation in the provision of these services, helping the activities of professionals working in this area. However, the literature is still scarce on the perception of these professionals regarding the benefits and challenges arising from the use of these innovations. In this sense, the objective of this article is to evaluate the perception of ophthalmologists and dentists in the use of AI technological innovations in relation to the benefits for patient care, as well as the challenges for its implementation and adoption. This is a qualitative research that was developed from data collected, through a questionnaire, with 18 health professionals, 10 ophthalmologists, and 8 dentists. As a result, it was observed that the main benefits found with the use of AI-assisted innovations were diagnostic support, mainly in increasing assertiveness and reducing the time to detect diseases. In addition, these innovations provided an increase in the time of the doctor-patient relationship, reflecting greater satisfaction of the users of these health services. The challenge presented in the implementation of innovations in ophthalmology and dentistry was the lack of incentives from health plans in the application of AI. Without financial incentives, the costs of these innovations become a significant barrier to adoption. To overcome the barrier related to cost, some ophthalmologists acquired equipment in partnership with other health professionals, enabling the sharing and rationalization of costs related to the technological resource. Finally, in the perception of both professionals (ophthalmologists and dentists), AI promotes innovations in health services, complementing and not substituting the clinical diagnosis of a specialized professional.

**Keywords:** Artificial Intelligence; Ophthalmology; Dentistry; Decision-making process, Patient care.

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## 1. Introduction

Technological innovations interfere in people's daily lives, facilitating existing processes or creating new problem-solving methods. In this sense, the use of Artificial Intelligence (AI) is revolutionizing different organizational contexts (Lobo, 2017), from manufacturing to the service sector, such as health (Dwivedi *et al.*, 2021; Alami *et al.*, 2020).

Among the areas of health, ophthalmology, and dentistry stand out because they are areas marked by the intense use of technology, mainly for obtaining images. In practice, access to technological innovations related to both AI and the Industry 4.0 context can contribute to the elimination of various types of waste and bottlenecks (Reis *et al.*, 2023; Reis *et al.*, 2022a) and quality improvement (Reis *et al.*, 2022b) both in key activities and in support activities such as purchasing (Araujo *et al.*, 2023), for example. In the case of ophthalmology, there are already several applications of tools related to innovation with the use of AI (Tan, Scheetz and He, 2019). Similarly, in dentistry, AI applications are rapidly evolving and their increasing application is due to the fact that it benefits dentists, improving the quality of patient care and simplifying protocols (Chen *et al.*, 2020).

However, according to Barros *et al.* (2020), publications on AI in healthcare are still limited. One of the major discussions is whether the machine will replace a human expert in the medical field and to what extent it will interfere with the decision-making process of the health professional (Alami *et al.*, 2020; Blease *et al.*, 2019). Innovations arising from the use of AI understand and stratify a large amount of data (Tan, Scheetz and He, 2019), but fail to understand what this represents for the patient. AI can contribute, for example, to the diagnosis, but it does not replace the professional's sensitivity in welcoming and psychologically supporting the patient (Mazzochi and Traiano, 2021; Cericato, Garbin and Fernandes, 2006).

In this sense, the objective of this research is to evaluate the perception of ophthalmologists and dentists in the use of AI technological innovations in relation to the benefits for patient care, as well as the challenges for

its implementation and adoption. With this, this work will seek to understand the effect of innovations in the decision-making process of professionals in these two areas of health, in addition to pointing out some perceptions about the impact on patient care. The study will allow health professionals and institutions to reflect on the implementation of AI tools from a practical point of view, obtaining information on several issues that involve this adoption.

## 2. Literature Review

Innovations in the health area resulting from the use of AI, especially those applied in ophthalmology and dentistry, provide professionals and patients with several benefits. However, professionals who are adept at using these AI technologies are also faced with challenges in adopting such innovations in their work routines. Thus, the theoretical framework will address the benefits and challenges of adopting AI in the two health areas mentioned.

### 2.1 Innovations in health services based on the use of AI

AI has revolutionized several industrial processes, including service delivery (Dodds *et al.*, 2022; Alami *et al.*, 2020). Among other areas of health, ophthalmology, and dentistry stand out for widely employing diagnostic imaging using AI (Kuiava *et al.*, 2021; Poomathi *et al.*, 2019).

AI innovations available in ophthalmology already aid in the diagnosis of Diabetic retinopathy, age-related macular degeneration, glaucoma, and retinopathy of prematurity (Tan, Scheetz and He, 2019). Fundus photography and Optical coherence tomography (OCT) are tools that have used deep learning to automate the screening and diagnosis of diseases and to increase the sensitivity of exams (Li *et al.*, 2021; Tan, Scheetz and He, 2019). Through OCT, it is possible to predict systemic cardiovascular risk factors, such as: age, sex, systemic blood pressure, and glycated hemoglobin (Ting, 2020).

Among the technologies used in dentistry, there is confocal laser endomicroscopy, which records subsurface microanatomical images for the analysis of cellular structure, which may be related to a new automatic approach for oral squamous cell carcinoma (Mazzochi and Traiano, 2021). In addition, computer-aided design and computer-aided manufacturing (CAD/CAM) technologies and the intraoral scanner can be mentioned (Moura and Pasini, 2020). The scanner, for example, makes optical impressions capable of collecting information about the shape and size of dental arches. It is used in different areas of dentistry such as: orthognathic surgery, endodontics, implantology, orthodontics and prosthesis (Moura and Pasini, 2020).

### 2.2 Benefits of using innovations in health services

The literature identifies the benefits of using innovation through the application of AI in healthcare. In ophthalmology, there has been an improvement in the accuracy and efficiency of diagnoses, an increase in patient safety, support for decision-making, a decrease in the incidence of errors, and an improvement in results with therapeutic decisions made for each patient (Kuiava, 2021; Ribeiro *et al.*, 2021, Korot *et al.*, 2020). The quality and excellence in medical care go beyond clinical care. In this context, AI seeks to ensure greater excellence in care by improving the patient's experience, and managing their expectations during their treatment (Barros *et al.*, 2020; Ting, 2020).

Another benefit of using innovations in ophthalmology is the possibility of telemedicine, which proves to be reliable in identifying diseases in their early stages in remote locations (Junior, 2019). Despite this contribution, scholars believe that the explanation of the diagnosis, the association with other diseases, and the decision regarding treatment are still up to the professional (Hazarika, 2020).

In dentistry, AI technologies, in addition to improving agility and effectiveness in diagnosis and clinical practice (Moraes, 2019), improve the reliability of diagnoses of complex oral diseases and have the potential to provide real-time information on suspicions (Mazzochi and Traiano, 2021).

To summarize the benefits of AI for the two health areas mentioned, Table 1 was structured.

Table 1: Benefits of AI in healthcare.

Field	Construct	Benefits	Authors
Ophthalmology	Aid in the diagnosis and treatment of diseases	It allows for faster and more accurate diagnoses, preventing the progression of changes in vision.	Kuiava <i>et al.</i> (2021)
		Allows to identify diseases in early stages in remote locations through telemedicine.	Junior (2019)
		It makes it easy to manage patient expectations during their treatment journey.	Ting (2020)
	Assistance in doctor x patient interaction	It makes it possible to improve medical care for patients.	Kuiava <i>et al.</i> (2021)
		It makes it possible to improve the quality of care with the patient, making it more humanized.	Ribeiro <i>et al.</i> (2021)
Dentistry	Aid in the diagnosis and treatment of diseases	Assists in diagnosis, planning, and dental treatment.	Moura and Pasini (2020)
		It makes the treatment more agile, effective, and comfortable for the professional and the patient.	Moraes (2019)
		Promote positive reflections among dentists and patients. Help explain the need for complex treatment alternatives.	Cericato, Garbin and Fernandes (2006)
	Assistance in doctor x patient interaction	It contributes to problem-solving and generates better working conditions for professionals. Contributes to high-quality patient care.	Mazzochi and Traiano (2020)

### 2.3 Innovation Challenges in Healthcare

Challenges are present in adopting recent research innovations. Among them, the changes in the routine of ophthalmological offices, and the difficulties of resistance and acceptance of the doctor and the patient to explore the potential of these innovations stand out (Li *et al.*, 2020; Tan, Scheetz and He, 2019). In addition, the high investment and the need for training necessary for this adoption stand out (Li *et al.*, 2020).

In dentistry, AI is still a challenge due to the lack of a database, lack of information, standardization of software, and professional experience to master these technologies (Mazzochi and Traiano, 2021). The challenge of using the intraoral scanner, for example, is also its high cost, which makes it a barrier to the wide use of professionals (Moura and Pasini, 2020). The numerous benefits of AI in dentistry were observed in the literature, however, its high cost, complexity, and system-specific training are emphasized (Cordeiro *et al.*, 2023a; Cordeiro *et al.*, 2023b; Moraes, 2019).

Finally, based on the literature, three main challenges can be highlighted: i) high acquisition cost, ii) lack of confidence in the diagnoses provided by the use of AI, and iii) difficulty in assigning responsibilities in the face of diagnostic and treatment failures. Regarding cost, it was observed that AI technologies are expensive, which makes their adoption difficult by professionals.

Table 2 presents the summary of AI challenges in the health area, presented by the studied authors.

Table 2: AI challenges in healthcare

Field	Construct	Challenges	Authors
Ophthalmology	Cost	High cost	Moura and Pasini (2020); Moraes (2019)
	Reliability	Challenges associated with implementing the technologies, include validation, patient acceptance, and end-user training. Patients' lack of confidence in the decision-making ability of the AI used.	Li <i>et al.</i> (2021) Groves and Kayyali (2013)
	Responsibility AI vs Professional	Difficulty assigning responsibilities in case of diagnostic errors.	Bonna and Sá (2021)
Dentistry	Cost	High cost	Moura and Pasini (2020); Moraes (2019)

	Reliability	Database limitation, lack of information and professional experience to master this technology. Patients' lack of confidence in the decision-making capacity of the AI used.	Mazzochi and Traiano (2021) Groves and Kayyali (2013)
	Responsibility AI vs Professional	Analysis of the dentist's performance, whether he acted with the necessary diligence or whether he acted with negligence, imprudence or clumsiness.	Bonna and Sá (2021)

### 3. Methods

This research is classified as descriptive, as it presents an exposition of the characteristics of certain populations or phenomena for the establishment of relationships between variables (Gil, 2002). In addition, it is characterized by the use of standardized techniques for data collection, such as the questionnaire. The research has a qualitative approach focusing on the opinions of ophthalmologists and dentists about the use of innovation, through the use of AI, in order to identify the benefits and challenges of adopting these innovations.

For data collection, a questionnaire containing 16 questions in Google Forms was used and the link was sent to the professionals. Responses were obtained from March 21 to April 22, 2022. A questionnaire with open and essay questions divided into four blocks was applied: i) characterization of the respondent, ii) innovative technologies used, iii) the benefits observed by adopting technologies, including an evaluation of the impact on the quality of care, the influence of the decision-making process and the level of confidence in innovations and, finally, iv) the challenges of using AI and the incentives given by the agreements.

The questionnaire was sent to an ophthalmology and dentistry professional, using Snowball sampling, which is a non-probabilistic sampling method in which new participants are recruited by other participants to compose the sample (Silva *et al.*, 2022). Snowball sampling can be useful for conducting research on people with specific characteristics that would otherwise be difficult to identify (Silva *et al.*, 2022).

The questionnaire was answered by 18 professionals, 10 ophthalmologists, and 8 dentists who work in the states of Minas Gerais and São Paulo (southeastern Brazil). These professionals serve both health plan networks and private individuals.

The data obtained with the application of the questionnaire were analyzed and elaborated, grouping the opinions of the participating professionals, and the result was converted into percentages.

### 4. Results

Of the 18 professionals interviewed, 90% of ophthalmology professionals and 60% of dentists use innovations that apply AI. Among the innovations explored in ophthalmology, "Optical coherence tomography (OCT)" and "fundus photography" were cited. In dentistry, it was the "intraoral scanner". Next, find the perception of health professionals regarding the benefits and challenges of adopting these technologies in their work contexts.

#### 4.1 Perception of the benefits of using innovation in ophthalmology and dentistry services

Analyzing the collected data, those received benefits in terms of assistance in diagnosing and treating diseases, in the interaction between the professional (ophthalmologist and dental assistant) and the patient, and in the improvement of performance indicators for care.

In relation to the doctor's diagnosis, it is considered that one of the greatest benefits concerns the aid in the diagnosis, highlighting the increase in assertiveness, reliability of the diagnosis, and the reduction in the time of detection of the disease.

*"[...] they reduce the time of detection of the disease because if they were done manually it would take longer, in the symptoms that are not detected in the routine exam, they help us to confirm a diagnostic suspicion, and also in the follow-up of the disease and follow-up of its treatment [...]"*. (Respondent 03).

Despite these benefits, professionals report that AI complements the diagnosis, but clinical examination is still very important. Thus, in their view, technology complements and does not replace human work. Even with AI helping in the diagnosis, most health professionals believe that the patient cannot define the diagnosis with AI alone.

*"[...] The professional is always necessary to evaluate and close the diagnosis with all the complementary exams and clinical evaluations [...]"* (Respondent 15).

Table 3 shows the agreement of professionals from the two areas analyzed regarding the benefits of AI.

**Table 3: Benefits of applying AI in ophthalmology and dentistry**

Field	Construct	Benefits
Ophthalmology	Aid in the diagnosis and treatment of diseases	100% of respondents believe that AI is complementary to the diagnosis made by the physician.
		70% reported having a high level of confidence in relation to the diagnosis made by the AI. 50% of these relate this level of confidence to the patient's health condition.
		80% say AI helps with a more accurate diagnosis.
	Assistance in doctor x patient interaction	80% do not believe that the patient can define his diagnosis only with the use of AI. Technology reduces diagnostic time, providing greater humanization of the doctor x patient relationship.
Dentistry	Aid in the diagnosis and treatment of diseases	100% of respondents agree with the need for coexistence between the use of AI and the clinical method.
		100% of respondents trust the diagnosis offered by AI. In this parameter, 50% believe that the patient's health does not interfere with the confidence level, and the other half think it is important to assess the patient's overall health status.
		87.5% say that the use of AI contributes to a more accurate and assertive diagnosis. 50% say it helps in planning and predicting treatment.
	Assistance in doctor x patient interaction	100% do not believe that the patient can define his diagnosis only as a result of the use of AI. AI allows the patient to have greater confidence in the relationship with the complicated dentist, which ends up improving the relationship between them.

**4.2 Perception of the challenges faced by professionals in the implementation of innovations in health services**

Regarding the challenges, challenges related to the high cost of acquisition, lack of confidence in the diagnoses provided by the use of AI, and the difficulty of assigning responsibilities in the face of diagnostic and treatment failures, in addition to the lack of incentives from health insurance were identified. Regarding cost, it was observed that AI technologies are expensive, which makes their adoption difficult by professionals.

The lack of accessibility for some is also related to the high cost of equipment.

*"[...] In João Monlevade/Minas Gerais, it was necessary for us to join five ophthalmologists to become partners in the OCT equipment, in which each one has the right to use one day of the week [...]"*. (Respondent 02).

Considering that the diagnosis may contain failures, it is important to understand those responsible for them. Thus, in view of these failures in diagnosis or conduct, most respondents agree that the responsibility would lie entirely with the professional.

*"[...]The responsibility is very great, the professional must first be able to interact with his patient, with time to extract all the necessary information from him, to order the complementary tests he deems necessary and to make the final decision [...]"* (Respondent 07).

The data presented in Table 4 refer to the results of variations in the common responses of ophthalmologists and dentists on the challenges in relation to the AI technologies used in each specialty. In addition, the table provides for the existence of incentives provided by health insurance in relation to complementary exams that use AI.

**Table 4: Challenges of AI application in ophthalmology and dentistry**

Field	Construct	Challenges
Ophthalmology	Cost	50% due to high cost.
	Reliability	30% are no longer using it due to low reliability in using recent technologies.

Field	Construct	Challenges
		70% believe that there may be a discrepancy between the AI and the clinical diagnosis, as in some cases it is only possible to identify the disease through imaging tests with AI.
		In case of diagnostic errors, the responsibility lies only with the professional was affirmed by 60% of the interviewees. The other 40% argue that responsibility should be shared.
	Responsibility AI vs professional	100% agree that the interpretation and orientation of the correct treatment is the role of the health professional.
	Health insurance incentives	90% are not encouraged.
Dentistry	Cost	75% no longer use AI due to high cost.
	Reliability	12.5% for preferring a clinical examination.
		62.5% said there may be discrepancies between diagnoses.
	Responsibility AI vs professional	100% agree that the professional is fully responsible for the diagnosis, as the most appropriate diagnosis and treatment is legitimate.
		75% agree that the professional is responsible for the error. The other 25% say it could be shared with AI.
	Health insurance incentives	Although most professionals do not work through an insurance plan, 100% believe that there is no incentive from health insurance plans for the use of these technologies.
Interaction with the patient	12.5% due to the difficulty of use in children.	

Still, in Table 4, most professionals answered that health insurance does not encourage the use of complementary exams to help in decision-making, even professionals admitting that complementary exams are useful and essential.

## 5. Discussion

This discussion section was structured based on the pillars of the research: the technologies explored by the two areas of health, and the benefits and challenges experienced by professionals in relation to the implementation of technologies.

### 5.1 Existing Technologies

The literature shows that the existing technologies in ophthalmology are: fundus photography and Optical Coherence Tomography (OCT) (Li *et al.*, 2021; Tan, Scheetz and He; 2019). The survey results indicate that 90% of the ophthalmologists who participated in the survey use these technologies.

In the area of dentistry, the literature addresses technologies: confocal laser endomicroscopy (Mazzochi and Traiano, 2021) and CAD/CAM technology; Intraoral scanner (Moura and Pasini, 2020), but it was observed that only the intraoral scanner technology is used and by 60% of respondents. With this, we can say that the use of AI in dentistry is less explored.

The use of innovations with the application of AI technologies in these two health areas is very focused on aiding diagnosis and not on treatment, as demonstrated in the literature (Hazarika, 2020; Ting, 2020).

### 5.2 Benefits

Telemedicine, identified in the literature (Junior, 2019) was classified in this research from the perspective of quality of care. Respondents highlighted support for the diagnosis decision as the most commented. In this context, the increase in assertiveness, the reduction in the time of detection of the disease, and the follow-up of the disease stand out.

From the data collection, it was observed that most of the professionals who participated in the research consider that the use of AI complements the analyzes made by them, not replacing the human diagnosis, which corroborates the studies of Mazzochi and Traiano (2021). They also point out that only with the use of AI, the patient cannot define his diagnosis, emphasizing the importance of the physician's role in the process, as mentioned by Tan, Scheetz and He (2019). Most professionals consider a sovereign clinical analysis.

There are also cases in which the diagnosis made by clinical examination may seem normal, however, when performing tests such as OCT, it is possible to detect the initial stage of the retinal disease due to diabetes. Even in this case, the clinical examination is essential to analyze the patient's health history and complaints, in addition to requesting tests that help confirm the diagnosis.

As reported by a dental surgeon, through the intraoral scanner, it is possible to make the diagnosis more visible, showing whether any treatment is necessary and the options offered. This visibility increases the patient's safety and confidence in relation to the professional, corroborating the study presented by Kulkarni (2020).

### 5.3 Challenges

The literature presents the following challenges with the use of AI: i) Interaction with the patient (Groves and Kayyali, 2013); ii) Cost (Moura and Pasini, 2020; Moraes, 2019); iii) AI vs Professional Responsibility (Bonna, 2021); iv) Reliability (Li *et al.*, 2021; Mazzochi and Traiano, 2021). Note that the challenges cited in the literature were corroborated by the collected data. The cost of adopting these technologies was highlighted as a significant barrier (Cordeiro *et al.*, 2023a; Cordeiro *et al.*, 2023b). Some ophthalmologists responded that to manage the cost challenge, for example, it was necessary to work with resource sharing. In João Monlevade (Province of Minas Gerais, Brazil), five of them bought the equipment in partnership, which is available to each one once a week.

In dentistry, many professionals are not insured, impacting, even more, the cost challenge because, sometimes, the patient is not willing to pay for the private examination. Some respondents reported that AI technologies are not cost-effective. When it is necessary to perform a specific exam, which uses AI, the professionals refer the patient only to perform the exam with another professional who has it.

Thus, in addition to corroborating the literature, reality brought two contributions. In the analyzed context, the lack of incentives from health insurance represents an important challenge for the adoption of AI. Another contribution was the identification of the difficulty of applying technologies to pediatric patients in dentistry, reflecting the need to adapt existing technologies to generate comfort in their use by children.

In ophthalmology, many physicians are insured, but health insurance advises professionals to carry out diagnoses with a smaller number of exams, due to the cost. Therefore, convincing the use of AI for health insurance is an important point about the importance of AI technologies, as it will often influence their use by health professionals.

Thus, for there to be an effective adoption of AI by these professionals, on the one hand, it is necessary to convince them in relation to reliability, and the benefits of quality. On the other hand, on the part of health insurance, it is important to show the possible gains in terms of costs, with the reduction in the need to carry out different tests to obtain an accurate diagnosis. In this case, the use of AI can reduce the overall cost of diagnosis.

## 6. Conclusion

The research was realized to evaluate the perception of ophthalmology and dentistry professionals about the use of innovations arising from the application of AI, seeking to understand the benefits and challenges of its application in these areas of health.

Even though it is widespread in some areas of knowledge, research with the application of AI in the health area is still incipient. The study showed that an AI can perform a diagnosis in a short period compared to a professional in the area, but it is not possible to replace the professional. Although the research findings cannot be generalized, the opinion of the 18 participating professionals is that the use of AI helps to aid in the diagnosis, in addition to increasing the reliability of the analyzed data. They also reinforce that the professional's relationship with the patient, in the opinion of the interviewees, is fundamental for the translation of the diagnosis and for the conduction of the treatment actions.

One of the great challenges pointed out by the research in the adoption of AI is the lack of incentives from health insurance, in addition to the high cost of implementing AI for use in nurses, requiring the apportionment of the value by more professionals to enable the acquisition of new technologies that aid in the diagnosis.

Among the limitations of the work, there is the evaluation of a reduced number of professionals and the regionalization of the sample, evidenced in the performance of these professionals in only two Brazilian states.

As future work, it is suggested to analyze in greater depth the impact of IA on the dynamics of health work. For this, this work can be analyzed from the perspective of cognitive ergonomics to identify the extent to which AI is replacing or complementing human work. Analyzing from the patient's point of view, it is suggested that research be carried out with the objective of evaluating their perception in relation to the transformation of their experience, in the professional *versus* patient interaction. In addition, when analyzing the effect of AI technologies on the work process of health professionals, it is possible to identify possibilities for improving these technological solutions, stimulating new innovations.

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