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Original Research Article

Assessment of the effectiveness of artificial intelligence-based oral screening solution in the diagnosis of dental calculus, stains, and dental caries (Logy AI oral screening solution)

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ABSTRACT

Background: The objective of this study was to clinically evaluate the precision of Logy AI's oral screening solution. This innovative module, driven by artificial intelligence, operates seamlessly through WhatsApp and as a standalone smartphone application. It is designed to detect various dental issues such as stains, calculus, and caries, utilizing images captured by a smartphone camera. The accuracy of the module was assessed by comparing its diagnoses with those made by dental professionals.
Methods: A prospective clinical study was conducted in Saveetha Dental College, a tertiary care hospital in the southern part of India with 325 patients. Smartphone images taken were sent to the Logy AI oral screening solution which predicted if the patient had any oral hygiene issues like stains, calculus, and caries. Patients were examined by a dentist with visual-tactile and orthopantomogram (OPG) examination and were documented. Both were compared.
Results: The accuracy of the Logy AI oral screening solution for the detection of stains, calculus, and caries was comparable with the dentist's diagnosis. The accuracy was 85% for caries, 97% for stains, and 83% for calculus. The sensitivity was 88% for caries, 89% for stains, and 82% for calculus.
Conclusions: The Logy AI oral screening module demonstrates potential as an efficient oral screening tool suitable for community-level deployment, particularly in remote regions lacking access to costly dental equipment and healthcare professionals. Its accuracy and efficiency make it well-suited for operation in low-resource settings. Moreover, it holds promise as a valuable home screening tool for individuals seeking to monitor their oral health proactively.

Keywords: Dentistry, Artificial intelligence, Oral hygiene

INTRODUCTION

The term artificial intelligence (AI) was coined in 1956 by John McCarthy during a conference held on this subject of AI. However, the possibility of machines being able to simulate human behaviour and thinking was raised earlier by Alan Turing who developed the turning test to differentiate humans from machines. According to previously assessed data, in real-time. Since then, computational power has grown to the point of instant calculations and the ability to evaluate new data.[1]

AI, in general, while not well defined, is the capability of a machine to imitate intelligent human behavior.[2]

As personal assistants (Siri, Alexa, and Google Assistant), automated mass transportation, aviation, and computer gaming, AI is integrated into our daily lives in many forms, as such. More recently, to improve patient care by speeding up processes and achieving greater accuracy, AI has also begun to be incorporated into medicine opening the path to providing better healthcare overall.[3] Aiding in the process of diagnosis and treatment of patients and augmenting physicians' capabilities. Radiological images, pathology slides, and patients' electronic medical records (EMR) are being evaluated by machine learning.[4]

The applications of these AI technologies like expert systems, Gameplaying, and theorem-proving, natural language processing, Image recognition, and robotics in various fields like telecommunication and aerospace have grown manifold. Technology has also revolutionized the field of medicine and dentistry in the last decade.[5] Since the 1980s, the inception of the field of intelligent tutoring systems has come a long way. Both these systems, augmented reality and virtual reality are being used widely in the field of dental education to create situations that simulate clinical work on patients and while training on live patients, eliminate all the risks associated with it. With the recent incorporation of artificial intelligence in intelligent tutoring systems like in the unified medical language system (UMLS); there is a huge improvement in the quality of feedback that the preclinical virtual patient provides the students.[6]

In high-quality training environments, the interactive interface allows the students to evaluate their work and compare it to the ideal. Several studies carried out on the efficacy of these systems have indicated that students attain a competency-based skill level at a faster rate than with traditional simulator units. Today artificial intelligence-based virtual dental assistants are available in the market.[7] As virtual assistants, this software can perform several simple tasks in the dental clinic with greater precision, less manpower and fewer errors than human counterparts.[8]

The portability and accessibility features of smartphones can provide an effective means for capturing images in less time and be less intimidating for children similar to dedicated digital oral cameras, smartphone cameras have zoom and flash features, as well as manual adjustments that allow easier capturing of intraoral or extra-oral images.[9] Recent studies reported that children and patients were enthusiastic and cooperative during photography and recording procedures with smartphones.[10]

For harnessing the advantages of ubiquitous smartphone imaging technologies and cloud-based computing and to build an easy-to-use, accurate tool, this study was designed to evaluate the accuracy of a suite of technologies and enhance the opportunity for dental screens for patients with otherwise limited access to dental care in collaboration with Public Health department of Saveetha Dental college Chennai.[11] The study aims to evaluate the sensitivity and accuracy of the Logy.AI oral screening solution, an artificial intelligence-based software developed by Nex Fitzap Pvt Ltd with the brand name Logy.AI in the screening of dental caries, stains, and calculus using only the free-hand images taken from smartphones.

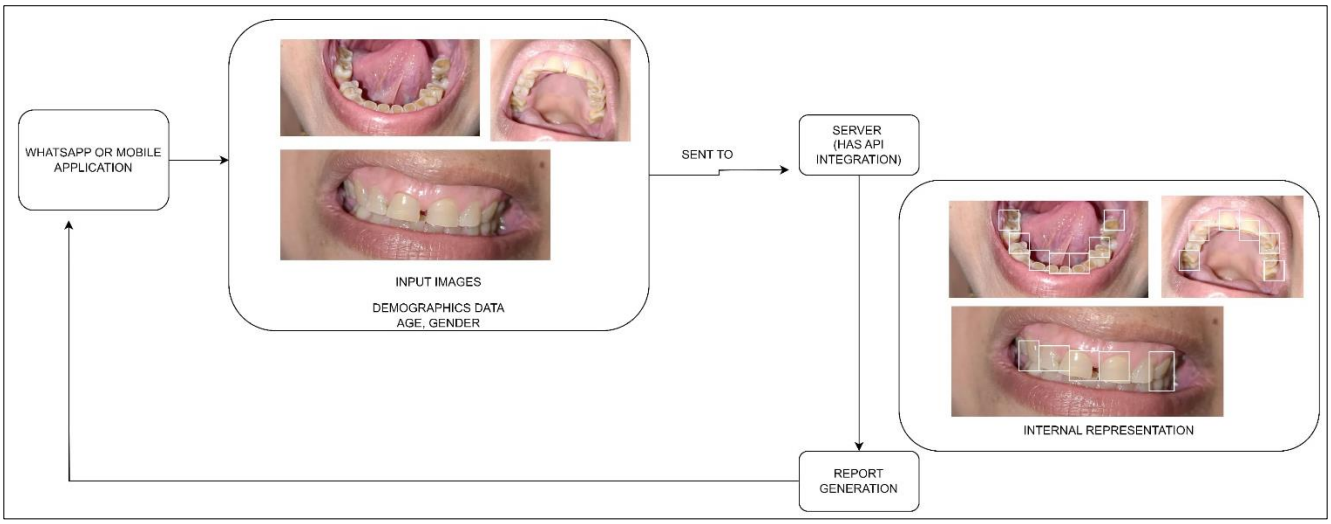

Figure 1: Logy.AI's oral screening solution flow.

METHODS

The study is conducted on the outpatients of Saveetha Dental College from the period of January - April 2021. A pilot study was conducted to test the sensitivity and accuracy of the application. The sample size of the main study was determined to be 325. Manual calculation method approximated from 322.25 - Nasser et al.[12] The pictures were taken without any intra-oral screening instruments in intra-oral frontal view, maxillary view, and mandibular view. Images were uploaded on the Logy.AI cloud platform. The images were annotated and also

ground truth evaluated with visual-tactile and orthopantomogram (OPG) examination by dentists on a digital platform provided by Logy.AI, who were blinded to make sure they were not biased. Ethical committee registration is also done with reference number IHEC/SDC/FACULTY/23/PERIO/247. To reduce the sampling bias, we have selected a large number of samples for the study. The app works in the following way: the name, age, and gender of the patient should be entered; brushing habit per day (once, twice, or more) is entered; number of dental visits per year (3 months once, 6 months once, once a year, nil); tobacco usage (yes or no); and the images will be uploaded.

The result will be shown in aspects of stains, calculus, and decay (low, moderate, and high), the likelihood of getting periodontal diseases, hypersensitivity, and malodor (unlikely, likely, and most likely), and the average oral hygiene status (poor, fair and good).

In the current study, the sensitivity and the accuracy of the application to detect the stains, calculus, and decay were analyzed. The accuracy of the application was counter-checked by the in-house dentists. The data were transformed and analyzed by statistical package for the social sciences (SPSS) software version 23.0.

Inclusion criteria

OPD patients who gave consent for the study and are above 18 years of age.

Exclusion criteria

OPD patients who did not give consent for the study and were below 18 years of age.

Outcome measures

The primary outcome measure was the accuracy of the oral screening solution for normal vs cataracts. The secondary outcome measures were the sensitivity, specificity, precision, and F1 score of the eye screening solution and also to estimate the accuracy of grading provided by the AI solution.

These metrics are often used in machine learning to evaluate the performance of classification models. The choice of metric depends on the specific problem being solved. For example, if it is important to minimize false negatives (e.g., in medical diagnosis), then sensitivity may be a more important metric than accuracy. On the other hand, if it is important to minimize false positives (e.g., in fraud detection), then specificity may be a more important metric.

Statistical analysis

Descriptive statistics like mean, standard deviation, and frequency were used for analyzing the demographic data like age and gender. Interquartile range (IQR) was computed for continuous variables. The computed lower and upper bounds using IQR were used to detect outliers in the data. Statistics such as accuracy, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and other similar stats were calculated along with their Clopper–Pearson 95% confidence intervals.

RESULTS

The results showed that the mean age of the study sample is 31.69±10.04. There were 70.06% males and 29.94% females present in the study (Figure 2). There was 52.78% in the 18-30 years age group, 41.05% in the 31-50 years old group, and 6.17% in the above 50 years group (Figure 3). The results stated showed that the model performs fairly well as a screening tool for stains, calculus, and caries. Table 1 describes the sensitivity and the accuracy of the application for various components like stains, calculus, and caries. The overall correlation among the doctors for stains, calculus, and caries detection is good. This makes the data suitable to be considered as a reference. The acceptable results on caries, stains, and calculus may hence be deemed suggestive of the AI's capability. Further inspection by our internal dentists suggested that in most cases the AI gave the right detection highlighting the point that the high sensitivity of the model across the doctors shows promise. Internal inspection by the internal doctors proved that the models performed well (empirically). Further research may be carried out to explore the limitations concerning detections. Methods should be used to counter the variability in judgment observed as part of this study.

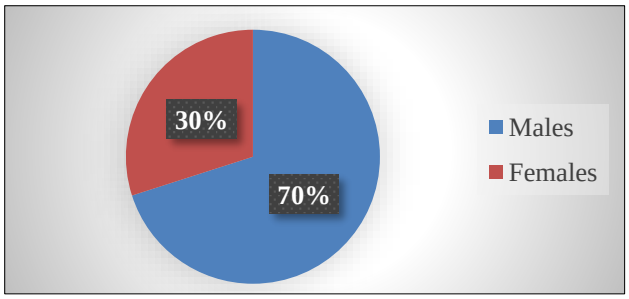

Figure 2: Gender distribution of study participants.

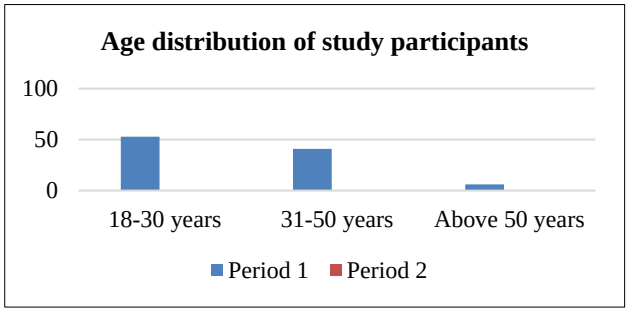

Figure 3: Distribution percentage versus age groups of study participants.

Table 1: Sensitivity and accuracy of the application for stains, calculus, and caries.

Dental conditions	Sensitivity (%)	Accuracy (%)
Stains	89	97
Calculus	82	83
Caries	88	85

DISCUSSION

In the field of dentistry, in most developing countries the majority of oral health professionals work in private practice and are clustered in cities, and remote and regional areas suffer from a significant shortage of dental practitioners.[13] Delay in seeking dental care could be considered a major contributor to poor oral health. This can happen not only in rural or remote areas where access is primarily limited by geography but also in underserved urban regions where access is limited by a lack of socioeconomic resources or complexity of life.[14]

In a study conducted in 2015, Hygiene therapists screened dental caries and periodontal disease with the help of an app with 0.87 – specificity. The process of capturing images using smartphones can therefore be non-invasive and less stressful than the usual oral examination. They suggested that hygiene-therapists could be used to screen for dental caries and periodontal disease.[15] Similarly, in our study, detection of oral diseases using AI-based applications has been analyzed which can be used in public-funded health systems.

In a study conducted in 2007, intra-oral images were taken using an intra-oral camera among children of 4-5 years old and the images were compared with intra-oral examination, it was concluded that there was no statistically significant difference between a visual examination and an examination using an intraoral camera, thus suggesting that the usage of other camera devices for taking intraoral images.[16]

In a similar study done in 2017, they introduced an AI-based application called OralCam that enables end-users to self-examination of five common oral conditions (diseases or early disease signals) by taking smartphone photos of one's oral cavity. They concluded that their application had a sensitivity of 0.787 over five conditions with high localization accuracy. They also concluded that most participants had no trouble using OralCam and interpreting the examination results.[17] Similar to our study, an AI-based pre-trained deep learning network can be used for the diagnosis of dental caries with the accuracy of identifying dental caries in premolars and molars and in proximal areas at 89%, 88%, and 82% respectively.[18]

Outside the aspects of clinical dentistry also, AI is shaping ways of assessing the practice of the field. AI in general and AI in dentistry or medicine, in particular, started gaining its foothold with the advent of data computing as well as cloud computing ability and availability of vast amounts of data collected.[19,20] With the vast amount of data, for example in the field of radiology, a specific algorithm was created which further helped in diagnosing and suggesting probable treatment options.[21]

Limitations

Adequate zoom and lighting conditions were not followed for every image. Certain types of dental caries like like interproximal caries or root caries were detected as normal.

CONCLUSION

The Logy.AI oral screening solution works fairly well as a screening tool using only smartphone images for the detection of stains, calculus, and caries. The AI tool has high sensitivity when it comes to stains, calculus, and dental caries. The next decade will prove, in particular, in healthcare where stakes are high, where the expectations for tangible AI applications are met by outcomes or if once again an AI winter buries hopes and excitement. Reasonable concerns about data protection and data security and about handing over critical medical decisions to computers is matters to evaluate. However, AI has the potential to revolutionize healthcare and, with it, dentistry; AI may assist in addressing the weaknesses harshly criticized in conventional dental care.AI will make dental care better, for dentistry and, specifically, dental research, has a role to ensure that AI will make patient care better, at lower costs, to the benefit of the system, including providers and the wider society.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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