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NEW PERSPECTIVE ARTICLE:

Potential of Artificial Intelligence to Generate Health Research Reports of Decayed, Missed and Restored Teeth

Potencial de la inteligencia artificial para generar informes de investigación sanitaria sobre dientes cariados, perdidos y restaurados

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ABSTRACT: This study aims to indicate the potential of artificial intelligence (AI) in epidemiological reports of decayed, missed and restored teeth. As a proof of concept our study model used panoramic x-ray images and an AI algorithm for tooth numbering, detection of the caries and restorations with accuracy over 80% for such diagnostic tasks. The output came as the number of decayed, missed and restored teeth according to patient´s age and the DMFT index (number of decayed, missing, and filled teeth) which varied from 3.6 (up to 20 years old) to 20.4 (+60 years old). Thus, it is suggested that AI is a promising method to automate health data collection through the analysis of x-rays.

KEYWORDS: Artificial intelligence; Radiology; Dentistry; Radiography.

RESUMEN: Este estudio tiene como objetivo indicar el potencial de la inteligencia artificial (IA) en los informes epidemiológicos de dientes cariados, perdidos y restaurados. Como prueba de concepto, nuestro modelo de estudio utilizó imágenes panorámicas de rayos X y un algoritmo de inteligencia artificial para la numeración de dientes, la detección de caries y las restauraciones con una precisión superior al 80 % para dichas tareas de diagnóstico. El resultado fue el número de dientes cariados, perdidos y restaurados según la edad del paciente y el índice CPOD (número de dientes cariados, perdidos y obturados) que varió de 3,6 (hasta 20 años) a 20,4 (+60 años). Por tanto, se sugiere que la IA es un método prometedor para automatizar la recopilación de datos de salud mediante el análisis de rayos X.

PALABRAS CLAVE: Inteligencia artificial; Radiología; Odontología; Radiografía.

Epidemiological surveys in oral health are an important mean for investigating and monitoring the main oral conditions affecting the population and serve as indicators for development and planning of health policies and actions (1-3). To this end, they must be periodic and regular to provide knowledge of the epidemiological reality of each location (2,4). World Health Organization (WHO) recommends including age groups in oral health reports in order to express age-specific conditions (1,2). However, several challenges occur in obtaining these health reports, such as training and shortage of human resources, time required for data collection and geographic access difficulties (5).

In Brazil, a country of 214 million of citizens, national reports of decay-missing-filled (DMF) indexes in Brazil are from 1986, 1996, 2003, and 2010. The last report in Brazil was produced with data from 26 state capitals and 150 cities with different sizes, where about 2000 professionals performed clinical exams on 37,519 individuals in the ages 5, 12, 15 a 19, 34 to 45, and 65 to 74 years old (1). To understand the importance of such data, the report from 2003 was the base to the national public policies that invested on the 390% increase of oral health equipments, the creation of 865 oral health treatment centers, the distribution of toothbrushes and toothpastes to 72 million citizens, and the increase in the distribution of fluoridated water (1).

In Dentistry, there are few recent studies exploring the use of artificial intelligence (AI) for different tasks and big data analysis can be one of these. In this context, dental radiographs are commonly used in clinical routine as a complementary clinical exam of adults and children, resulting in large sets of readily available data (6). In addition to this, studies have shown the (AI) being capable of diagnosis (7) of caries lesions (8-10), restorations (8,11,12) and missing teeth) (8,12). Therefore, it is believed that when these systems are robust enough for their clinical application, they can favor the automated generation of oral health reports, e.g. of the DMFT index (number of decayed, missing, and filled teeth). In this sense, it is considered that the use of AI in the analysis of x-rays can offer a promising method for epidemiological surveys in oral health, optimizing time, financial cost, workload and efforts of trained professionals.

In this scenario, the authors of this Letter to the Editor carried out a test to explore such an idea (approved by the local Research Ethics Committee, CAAE 51238021.2.0000.5419). A set of 1.000 panoramic radiographs were inputted in an AI algorithm, developed by research group (13, 14) able to number teeth and detect dental

restorations and large dental caries with sensitivity and specificity of over 80%.

The test proposed delivered the absolute number of healthy, decayed, restored, and missing teeth in the data set analyzed. It was possible, for example, to observe a DMFT index of missing teeth as 0.3 considering images from patients up to 20 years old and of 12.1 for patients over 60 years old. For restored teeth the index increased twice from patients up to 20 years (DMFT=3.0) to patients between 20-40 years old (DMFT=7.0). These preliminary results suggest that big data composed of dental panoramic radiographs offer a promising method for practical epidemiological surveys in oral health due to less demands in time, financial cost, workload, and efforts of trained professionals (Table 1 and Figure 1).

Table 1. DMFT index of the study sample from the AI analyzing the dataset of panoramics.

Teeth		Age Group				
		Up to 20 years	21-40 years	41-60 years	61+ years	Total
Missing	N	86	302	314	113	815
	Minimum	0	0	0	0	0
	Average	0.3	1.7	7.0	12.0	5.0
	Standard deviation	0.7	2.9	7.1	8.0	6.8
	Median	0	0	5	11	2
	Maximum	3	27	28	27	28
Decayed	N	86	302	314	113	815
	Minimum	0	0	0	0	0
	Average	0.4	0.9	1.4	1.2	1.1
	Standard deviation	1.0	1.6	1.7	1.5	1.6
	Median	0	0	1	1	0
	Maximum	7	13	8	7	13
Restored	N	86	302	314	113	815
	Minimum	0	0	0	0	0
	Average	3.1	7.7	10.7	8.0	8.4
	Standard deviation	3.5	5.3	5.8	5.4	5.8
	Median	3	8	11	8	8
	Maximum	18	22	26	20	26
DMFT	N	86	302	314	113	815
	Minimum	0	0	4	7	0
	Average	3.6	9.9	18.2	20.4	13.9
	Standard deviation	4.2	6.4	4.7	5.0	7.7
	Median	3	9	18	20	15
	Maximum	20	27	28	28	28

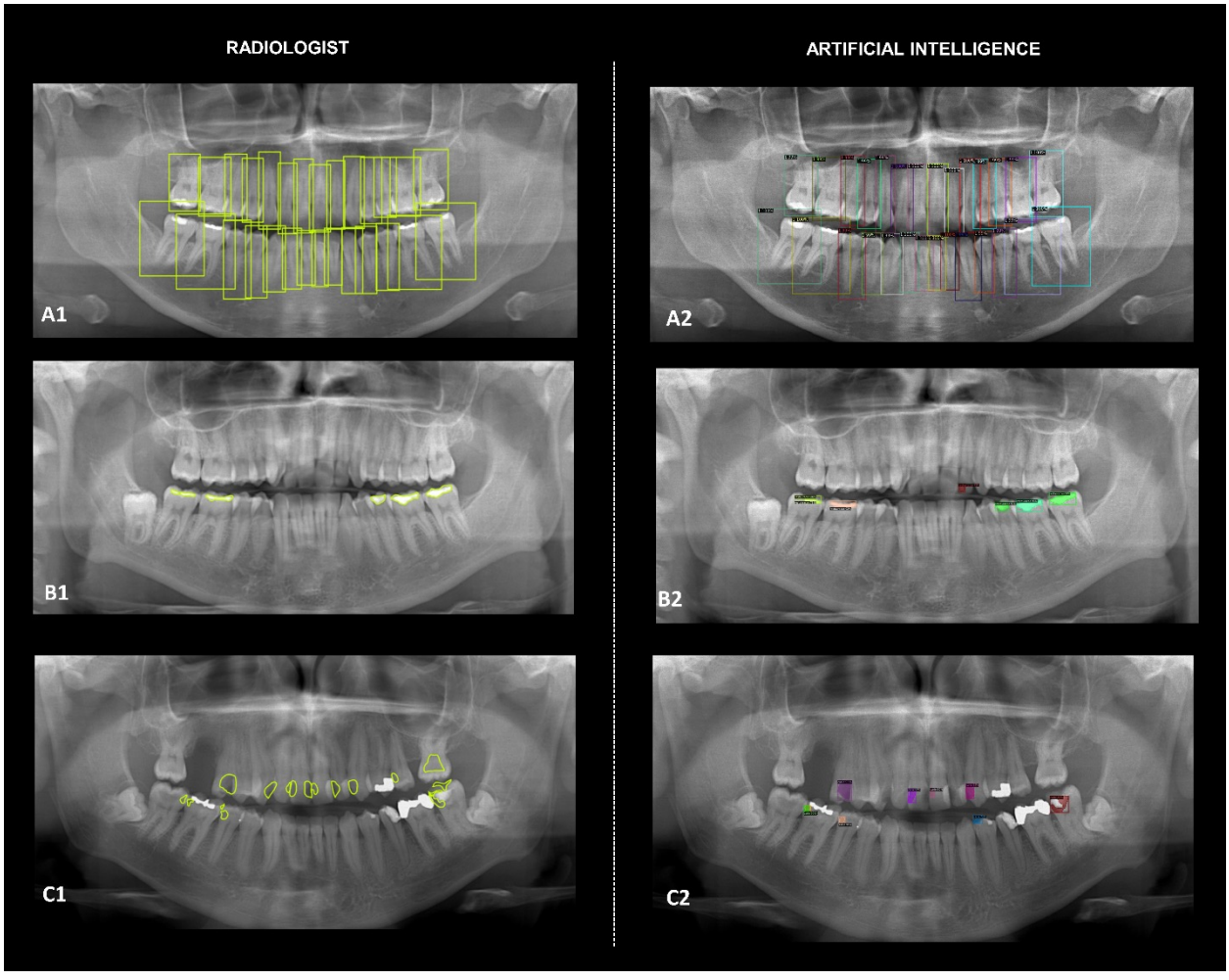

Figure 1. Examples of detection of tooth (bounding box) (A), segmentation of dental restorations (B) and carious lesions (C) on panoramic radiographs. (1) Labeling performed by the radiologist; (2) labeling performed by AI algorithm (Faster and Mask R-CNN adapted).

Thus, from the point of view of its applicability, the use of AI in the analysis of radiographs has potential to assist epidemiological studies both at regional and national levels, but not to replace field work with the presence of professionals who evaluate various oral/dental conditions. In this sense, it is important that health managers know the potential and applicability of AI as an auxiliary tool for generating oral health reports, especially in the time intervals when field research is not being carried out, as a complement surveillance model in health.

DISCLOSURE

The authors reported no conflicts of interest.

AUTHOR CONTRIBUTION STATEMENT

Conceptualization and design: E.D.C. and C.T.
Literature review: E.D.C.
Methodology and validation: E.D.C., J.A.C., B.A.G.Z, H.G.A, C.O.S. A.A.M. and C.T.
Formal analysis: E.D.C., J.A.C., B.A.G.Z., H.G.A, C.O.S. A.A.M and C.T.
Investigation and data collection: E.D.C., J.A.C., B.A.G.Z., H.G.A, C.O.S. A.A.M. and C.T.
Resources: A.A.M. and C.T.
Data analysis and interpretation: E.D.C., J.A.C., B.A.G.Z., H.G.A, C.O.S. A.A.M and C.T.
Writing-original draft preparation: E.D.C.
Writing-review & editing: E.D.C., J.A.C., B.A.G.Z., H.G.A, C.O.S. A.A.M and C.T.
Supervision: C.T.
Project administration: C.O.S, A.A.M. and C.T.
Funding Acquisition: C.T.

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REFERENCES

1. Brasil. Ministério da Saúde. Secretaria de Atenção à Saúde. Secretaria de Vigilância em Saúde. SB Brasil 2010: Pesquisa Nacional de Saúde Bucal: resultados principais / Ministério da Saúde. Secretaria de Atenção à Saúde. Secretaria de Vigilância em Saúde. – Brasília : Ministério da Saúde, 2012. 116 p. (Accessed February 27, 2023). Available in: https://bvsms.saude.gov.br/bvs/publicacoes/pesquisa_nacional_saude_bucal.pdf
2. Roncalli A.G., Silva N.N., Nascimento A.C., Freitas C.H.S.M., Casotti E., Peres K.G., Moura L., Peres M.A., Freire M.C.M., Cortes M.I.S., Vettore M.V., Paludetto Júnior M., Figueiredo N., Goes P.S.A., Pinto R.S., Marques R.A.A., Moysés S.J., Reis S.C.G.B., Narvai P.C. Relevant methodological issues from the SBBrasil 2010 Project for national health surveys. Cad Saude Publica. 2012; 28 Suppl: s40-57. doi: https://doi.org/10.1590/s0102-311x2012001300006
3. Brasil. Relatório da consulta pública do projeto técnico da pesquisa nacional de saúde bucal 2020. SB Brasil 2020. 35 p. (Accessed February 27, 2023). Available in: http://189.28.128.100/dab/docs/portaldab/documentos/cgsb/RelatorioConsultaPublicaSBBrasil.pdf
4. Azevedo J.S., Azevedo M.S., Oliveira L.J.C., Correa M.B., Demarco F.F. Needs for dental prostheses and their use in elderly Brazilians according to the National Oral Health Survey (SBBrazil 2010): prevalence rates and associated factors. Cad Saude Publica. 2017; 33 (8): e00054016. doi: https://doi.org/10.1590/0102-311X00054016
5. Miyazaki H., Jones J.A., Beltrán-Aguilar E.D. Surveillance and monitoring of oral health in elderly people. Int Dent J. 2017; 67 Suppl 2 (Suppl 2): 34-41. doi: https://doi.org/10.1111/idj.12348
6. Hosny A., Parmar C., Quackenbush J., Schwartz L.H., Aerts H.J.W.L. Artificial intelligence in radiology. Nat Rev Cancer. 2018; 18 (8): 500-510. doi: https://doi.org/10.1038/s41568-018-0016-5
7. Heo M.S., Kim J.E., Hwang J.J., Han S.S., Kim J.S., Yi W.J., Park I.W. Artificial intelligence in oral and maxillofacial radiology:

what is currently possible? Dentomaxillofac Radiol. 2021; 50 (3): 20200375. doi: https://doi.org/10.1259/dmfr.20200375

8. Başaran M., Çelik Ö., Bayrakdar I.S., Bilgir E., Orhan K., Odabaş A., Aslan A.F., Jagtap R. Diagnostic charting of panoramic radiography using deep-learning artificial intelligence system. Oral Radiol 2022; 38 (3): 363-369. doi: https://doi.org/10.1007/s11282-021-00572-0
9. Bayrakdar I.S., Orhan K., Akarsu S., Çelik Ö., Atasoy S., Pekince A., Yasa Y., Bilgir E., Sağlam H., Aslan A.F., Odabaş A. Deep-learning approach for caries detection and segmentation on dental bitewing radiographs. Oral Radiol. 2022; 38 (4): 468-479. doi: https://doi.org/10.1007/s11282-021-00577-9
10. Chen X., Guo J., Ye J., Zhang M., Liang Y. Detection of proximal caries lesions on bitewing radiographs using deep learning method. Caries Res. 2022; 56 (5-6): 455-463. doi: https://doi.org/10.1159/000527418
11. Abdalla-Aslan R., Yeshua T., Kabla D., Leichter I., Nadler C. An artificial intelligence system using machine-learning for automatic detection and classification of dental restorations in panoramic radiography. Oral Surg Oral Med Oral Pathol Oral Radiol. 2020; 130 (5): 593-602. doi: https://doi.org/10.1016/j.oooo.2020.05.012
12. Chen S.L., Chen T.Y., Huang Y.C., Chen C.A., Chou H.S., Huang Y.Y., Lin W.C., Li T.C., Yuan J.J., Abu P.A.R., Chiang W.Y. Missing teeth and restoration detection using dental panoramic radiography based on transfer learning with CNNs. IEEE Access 2022; 10: 118654-64. doi: https://doi.org/10.1109/ACCESS.2022.3220335
13. Costa E.D., Gaêta-Araujo H., Carneiro J.A., Zancan B.A.G., Baranauskas J.A., Macedo A.A.M., Tirapelli C. Development of a dental digital dataset for research in artificial intelligence: the importance of labeling performed by radiologists. Oral Surg Oral Med Oral Pathol Oral Radiol. 2023 Dec. doi: https://doi.org/10.1016/j.oooo.2023.12.006
14. Carneiro J.A. Enhanced tooth segmentation algorithm for panoramic radiographs. [dissertation]. Ribeirão Preto: Universidade de São Paulo, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto; 2023 [cited in 2024-03-10]. doi:10.11606/D.59.2023.tde-20022024-073306