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Ensino mediado por tecnologia: uma abordagem possível em tempos de pandemia.

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Orientador: Prof. Dr. André Ferreira Leite

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Aprovada em 03 de outubro de 2023.

BANCA EXAMINADORA DE DEFESA

Prof Dr André Ferreira Leite – Presidente
University of Brasília, Brazil

Profª Drª Eliete Neves da Silva Guerra
University of Brasília, Brazil

Profª Drª Deborah Queiroz de Freitas França
Piracicaba Dental School, University of Campinas (UNICAMP), Brazil

Prof Dr Rubens Spin-Neto
Aarhus University - Denmark

Profª Dr Frederico Sampaio Neves - Suplente
Federal University of Bahia, Brazil

Dedico este trabalho à minha família, pela força, incentivo e apoio incondicionais.

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Aos que faleceram de COVID-19, meus mais profundos sentimentos. Que a morte de cada um de vocês não seja em vão. Esse trabalho é dedicado a vocês.

"A educação não é preparação para a vida; A educação é a própria vida."
John Dewey

"Se ensinarmos os alunos de hoje como nós ensinamos ontem, roubamos deles o amanhã."
John Dewey

RESUMO

O presente trabalho é fruto do cenário ímpar vivido pela humanidade, protagonizado pela pandemia de COVID-19, somado ao inédito desenvolvimento tecnológico, o qual foi direcionado para amenizar as consequências do isolamento social. Com o objetivo de averiguar as alterações decorrentes da restrição de mobilidade, tanto no âmbito educacional quanto no de saúde, e quais ferramentas tecnológicas puderam operacionalizar a resolução de problemas nesse contexto, esta tese contempla um estudo sobre o impacto da COVID-19 no ensino de pós-graduação em cirurgia buco-maxilo-facial em um hospital público brasileiro, uma revisão sistemática sobre o panorama do ensino de odontologia aliado aos recursos tecnológicos utilizados para a sua manutenção durante o início da pandemia, e uma revisão de texto e opinião sobre os desafios e as vantagens da inserção de inteligência artificial no ensino de radiologia. Além disso, foram realizados uma revisão sistemática focada no uso de análise radiômica (nova tecnologia utilizada no diagnóstico por imagem baseada em inteligência artificial) em alterações ósseas dos maxilares, e um trabalho que reporta a criação de um protótipo de aplicativo de celular com a finalidade de ajudar alunos e pacientes remotamente.

Como resultados, observou-se que a pós-graduação teve como principal prejuízo a redução em 40% do número de cirurgias realizadas. Já os cursos de odontologia conseguiram amenizar os impactos das medidas restritivas com o uso de novas e já existentes tecnologias, e os melhores resultados foram com aquelas que permitiram aulas síncronas, com destaque para a plataforma Zoom™. Ainda, foi verificado que o uso de inteligência artificial nos currículos de radiologia já é um consenso. A análise radiômica se mostrou alto potencial para auxiliar quantitativamente o radiologista no diagnóstico e classificação de doenças ósseas dos maxilares. Portanto. a conjuntura aponta para a importância de ampliar e intensificar o uso de ferramentas tecnológicas em educação e saúde. O futuro das tecnologias no âmbito educacional e de saúde é promissor, pois engloba abordagens humanistas com foco na acessibilidade, personalização e eficiência.

PALAVRAS-CHAVE: COVID-19; Educação à distância; Telessaúde; Tecnologia Educacional; Inteligência Artificial

ABSTRACT

This work is the result of the unique scenario experienced by humanity, caused by the COVID-19 pandemic, in addition to the unprecedented technological expansion, which was aimed at mitigating the consequences of social isolation. With the objective of investigating changes arising from mobility restrictions, both in educational and health care areas, and identifying useful technological tools in this context, this thesis includes a study on the impact of COVID-19 on postgraduate education in oral and maxillofacial surgery in a Brazilian hospital, a systematic review of the dentistry teaching panorama combined with the technological resources used for its maintenance during the beginning of the pandemic, and a text and opinion systematic review on the challenges and advantages of inserting artificial intelligence in radiology curriculum. In addition, another systematic review focused on the application of radiomics (a new technology used in diagnostic imaging based on artificial intelligence) in pathologic bone alterations of the jaws was published. Finally, a work about the creation of a mobile application prototype with the purpose of helping students and patients remotely was developed. As result, it was reported that the postgraduate course had a 40% decrease in surgery procedures as the main drawback. Dentistry courses alleviated the effects of mobility restrictions by harnessing both new and established technologies. The most favorable outcomes were observed in programs that facilitated synchronous classes, with a particular focus on the Zoom™ platform. Furthermore, it was verified that the insertion of artificial intelligence in radiology curriculum is already a consensus. Moreover, radiomic analysis demonstrated high potential to quantitatively support radiologists in the diagnosis and classification of jaw bone diseases. The whole context indicated the importance of broadening and enhancing the use of technological tools in health care and education. The future of technologies in the educational field and health assistance is promising, by the inclusion of humanistic approaches focused on accessibility, personalization, and efficiency.

KEYWORDS: COVID-19; E-learning; Telehealth; Technology; Artificial Intelligence

LISTA DE ABREVIATURAS E SIGLAS

CFO	Conselho Federal de Odontologia
IA	Inteligência Artificial
PIB	Produto Interno Bruto
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
TICs	Tecnologias de Informação e Comunicação
Unesco	Organização das Nações Unidas para a Educação, a Ciência e a Cultura
UNICEF	Fundo de Emergência Internacional para Crianças das Nações Unidas

SUMÁRIO

CAPÍTULO 1

1.1 Introdução

A infecção pelo vírus SARS-CoV-2 é uma zoonose originária de morcegos e surgiu primeiramente em Wuhan, China, em 2019[1]. Alastrou-se rapidamente por todo o mundo, e a pandemia de COVID-19 foi então estabelecida. De sintomas inespecíficos, incluindo febre, tosse, cansaço e perda de paladar e olfato, apresenta rápida disseminação e alto potencial de letalidade[1]. Com o intuito de diminuir as taxas de transmissão do vírus, medidas restritivas foram adotadas pela maioria dos países, como tentativa de manter o atendimento hospitalar para os casos mais graves e também para lograr tempo visando o desenvolvimento de vacinas e terapias adequadas[2]. Nesse período, milhões de vidas foram perdidas e inúmeras novas patologias relacionadas foram relatadas. Felizmente, graças à aplicação das vacinas e ao investimento em pesquisas, somados aos esforços incessantes de pesquisadores de distintas partes do mundo, o número de infectados que chegam a óbito tem diminuído de forma drástica, e as sequelas observadas mais brandas. Vale ressaltar que o acesso às vacinas ainda é bastante limitado em países com poucos recursos econômicos, reflexo da relação mundial colonialista.

Devido ao fechamento das escolas e universidades como medida restritiva, a rápida migração do modelo presencial para o modelo à distância via Internet visou à continuidade do ensino e exigiu dos professores resiliência, capacitação tecnológica, criatividade pedagógica e desenvolvimento de novos métodos de avaliação de conhecimento dos alunos. Seria impossível levar tamanha transformação adiante sem os inúmeros recursos de software já desenvolvidos, como salas de reunião online, jogos, chats, vídeos e redes sociais, os quais foram adaptados às necessidades daquele momento.

Ademais, o medo de ser infectado levou milhares de pacientes crônicos e portadores de doenças graves a cancelarem suas consultas diagnósticas e periódicas ambulatoriais, resultando em um agravamento de sua condição.

O presente trabalho é fruto do cenário ímpar vivido pela humanidade nos anos de 2020 a 2022, protagonizado pela pandemia de COVID-19 e todas as restrições por ela impostas, somado ao inédito desenvolvimento tecnológico, o qual foi direcionado para amenizar as consequências do isolamento social.

1.2 Revisão de Literatura

O domínio da tecnologia é instrumento das relações de poder social e mola propulsora da concorrência no capitalismo moderno[3]. Em sequência histórica, a revolução industrial é a materialização de uma revolução tecnológica no próprio modo de produção capitalista iniciado com a revolução mercantil, que ampliou enormemente os espaços e o alcance das relações de produção. Desde então, as mudanças na base técnica — da eletromecânica à microeletrônica na passagem do século XX para o século XXI, chegou-se à "era digital", potencializada com o advento da pandemia da COVID-19. Notadamente, o processo generalizado de automação e de suporte digital ao trabalho mantém a divisão internacional do trabalho, ou seja, países ricos são produtores de artefatos e dispositivos tecnológicos, enquanto países desfavorecidos economicamente são dependentes dos grandes conglomerados que hegemonizam as tecnologias de informação e comunicação (TICs), a indústria 4.0 (transformação digital sobre as formas como as empresas fabricam, aprimoram e distribuem os seus produtos, digitalizam seus processos e criam modelos de negócios mais competitivos), a robótica, a IA e as gigantescas plataformas digitais[4].

Durante a pandemia observou-se a ampla aplicação das TICs nas diversas modalidades de trabalho remoto — teletrabalho, teleatendimento, tele-educação, teleconsultas em saúde, teleterapias etc, existentes até então de modo complementar — que, devido ao isolamento social passaram a ser adotadas em larga escala, em todas as áreas e setores do mercado de trabalho público e privado, momento em que o mundo funcionou como um grande laboratório, viabilizando a exponencial ampliação da produtividade do trabalho mediante a redução do trabalho vivo e a maximização do trabalho morto. Dessa forma, o uso digital, como suporte da informação, teve nas TICs a base para o desenvolvimento relacionado a um "novo paradigma" calcado na coleta massiva de dados (datafícação), ao processamento inteligente por meio de algoritmos e sistemas de IA e à oferta de serviços personalizados e moduladores de comportamentos, sobretudo por meio de aplicativos (apps) para cada vez mais atividades[5].

O ensino remoto em tempos pandêmicos levou mais de 1,5 bilhão de alunos do mundo a tornarem suas casas um reduto escolar, acarretando em consideráveis mudanças em comportamentos individuais e coletivos assim como em processos pedagógicos. Aproximou famílias e escolas, mas também aumentou a evasão, as desigualdades sociais e as barreiras de acessibilidade digital[6].

As tecnologias asseguraram a continuidade do ano letivo diante da necessidade de medidas restritivas em prol da saúde pública. Dispositivos móveis, principalmente celulares, notebooks e tablets, assim como plataformas de comunicação, softwares de aprendizagem e recursos em mesas pedagógicas conseguiram impulsionar a capacidade cognitiva e socioemocional dos alunos e os incentivaram a serem mais investigativos e a construírem a compreensão por meio da experimentação e recursos lúdicos. Observou-se que as tecnologias educacionais permitem personalizar o aprendizado, melhoram a retenção de informações e aumentam o engajamento, além de dinamizarem a rotina de alunos e professores da mesma forma que estimulam o senso de colaboração, criatividade e alfabetização digital[6].

Entretanto, no final do ano de 2021, o Banco Mundial, em parceria com a Unesco e o UNICEF, publicou o Relatório "The State of the Global Education Crisis: A Path to Recovery"[7], no qual expõe a magnitude da crise educacional decorrente do isolamento. Estima-se que esta geração de estudantes agora corre o risco de perder, em valor presente, US$ 17 trilhões em ganhos durante a vida, ou cerca de 14% do PIB global de hoje, como resultado do fechamento de escolas por causa da pandemia. Além disso, o relatório mostra que, em países de baixa e média renda, a proporção de crianças que vivem em pobreza de aprendizagem – 53% antes da pandemia – poderia chegar a 70%, dado os longos períodos em que as escolas estiveram fechadas e a inacessibilidade global do ensino remoto para garantir a continuidade da aprendizagem durante o fechamento das escolas. Salvo algumas exceções, as tendências gerais sugerem que a crise exacerbou as desigualdades na educação.

Observou-se que crianças de famílias de baixa renda, pessoas com deficiência e meninas tinham menos probabilidade de acessar o aprendizado remoto do que seus pares. Muitas vezes, isso se devia à falta de tecnologias acessíveis e à indisponibilidade de eletricidade, conectividade e equipamentos, bem como discriminação e normas de gênero, o que levou ao aumento no risco de enfrentar o trabalho infantil, a violência contra a mulher, o casamento precoce e a gravidez. Notou-se também que os estudantes mais novos tiveram menos acesso ao ensino remoto e foram, portanto, mais afetados do que os estudantes mais velhos, especialmente as crianças em idade pré-escolar. Ainda, foi visto que o impacto prejudicial na aprendizagem afetou desproporcionalmente os mais marginalizados ou vulneráveis e que as perdas foram maiores para estudantes de nível socioeconômico mais baixo de países como Gana, México e Paquistão. De acordo com o relatório, mais de 200 milhões de estudantes viviam em países de baixa e média renda que não estavam preparados para implantar o ensino remoto durante o fechamento emergencial de escolas[7].

Com o intuito urgente de resgatar os índices de aprendizagem, consta no relatório Missão: Recuperando a Educação 2021 (Mission, Recovering Education 2021)[8], produzido pelo Banco Mundial, a Unesco e o UNICEF a recomendação principal de reabertura de escolas. Em longo prazo, recomenda-se que os países devem considerar investir em ambientes de aprendizagem digital para todos os estudantes, reforçar o papel de pais, famílias e comunidades na aprendizagem, garantir que os professores tenham apoio e acesso a oportunidades de desenvolvimento profissional de alta qualidade e aumentar os investimentos em educação.

Portanto, a situação de pandemia intensificou a reflexão sobre as novas maneiras de ensinar à medida que evidenciou disparidades estruturais entre os países e entre os sistemas públicos e privados. Expôs a urgência da equidade na educação ao passo em que confirmou a essencialidade do professor no processo de aprendizagem. Tal contexto posicionou a tecnologia como viabilizadora e catalisadora do sistema educacional. A conjuntura aponta para a importância de ampliar e intensificar o uso dessas ferramentas e adoção mais ampla do modelo híbrido de educação. Além de otimizar tempo e recursos, encoraja o pensamento crítico, a capacidade de solucionar problemas e o protagonismo do aluno no processo de aprendizado. Por essa razão, é legítimo o anseio para melhorar a infraestrutura digital e estimular a equidade. O futuro das tecnologias educacionais é promissor, pois engloba abordagens pedagógicas humanistas com foco na acessibilidade, personalização e eficiência[6].

Já no âmbito do atendimento de pacientes, a tecnologia também exerceu importante papel durante o período de isolamento social. A telessaúde foi capaz de viabilizar ações de educação, assistência, gestão, pesquisa, prevenção de agravos e promoção de saúde, transpondo barreiras temporais, sociais, geográficas e culturais[9]. Especificamente na área odontológica, o Conselho Federal de Odontologia (CFO) publicou no dia 4 de junho de 2020 a resolução CFO 226[10], que regulamentou o exercício da odontologia a distância, com o objetivo de evitar a disseminação do SARS-CoV-2. Observou-se que, além de ter proporcionado o acesso aos cuidados à saúde bucal com um custo reduzido, eliminando disparidades existentes entre comunidades rurais e urbanas, também serviu como apoio à tomada de decisão do cirurgião-dentista[9,11,12]. Dessa forma, a teleodontologia despontou como uma ferramenta viável e eficiente para dar continuidade ao processo de assistência odontológica à distância, sendo adotada em diversos países, inclusive por instituições de ensino odontológico. Ressalta-se que, no Brasil, a prestação remota de serviços relacionados a todas as profissões da área de saúde foi regulamentada pela Lei n. 14.510, de 27 de dezembro de 2022, sob fiscalização do exercício profissional e normatização ética conduzida pelos respectivos conselhos federais. Embora as inovações tecnológicas, incluindo a teleodontologia, promovam uma eficiência nos atendimentos em saúde, podem trazer alguns riscos principalmente em relação à violação da proteção de dados, sendo indicado o emprego de métodos de segurança eficazes como assinatura digital, sistemas biométricos e criptografia[13].

Por fim, dentre tecnologias utilizadas no enfrentamento ao novo coronavírus, a IA ganha posição de destaque por sua efetividade. A decisão do uso da IA pelas áreas de saúde e educação está alinhada a uma das principais ideias filosóficas que apoiam os conceitos de certo e errado: o utilitarismo. Dessa forma, a IA passou a ser entendida como a revolução digital do momento, sendo apresentada como alternativa tecnológica para lidar com a crise sanitária. Os primeiros estudos de IA datam do final do período da Segunda Guerra Mundial, quando Alan Turing publicou o artigo “Computing Machinery and Intelligence”[14]. Por volta de 1956, o professor universitário John McCarthy designou o termo Inteligência Artificial durante a conferência “O Eros Eletrônico”, em Darmouth College[15]. Dentre os benefícios da IA estão a automação e otimização de processos, ou seja, tarefas que englobam grande volume de dados e de cálculos matemáticos, e que antes levavam um grande número de pessoas para executá-las e estavam, portanto, sujeitas a muitas falhas, podem agora ser realizadas por máquinas capazes de “imitar” a capacidade humana de tomar decisões e solucionar problemas através do cruzamento de dados, percepções e ideias[16, 17].

1.3 Objetivos da Tese de Doutorado

Com o intuito de averiguar as alterações decorrentes da restrição de mobilidade, tanto no âmbito educacional quanto no de saúde, e quais ferramentas tecnológicas puderam operacionalizar a resolução de problemas nesse contexto, foram produzidas pesquisas relacionadas a esses temas.

Os eixos de discussão desta tese são o uso de novas tecnologias para o ensino de odontologia, bastante difundido durante a pandemia de COVID-19, e a análise de novo método de leitura e interpretação de imagens diagnósticas por meio da Inteligência Artificial. São objetivos principais desse trabalho:

1. Identificar alterações ocorridas dentro do ensino de Odontologia decorrentes da pandemia de COVID-19;
2. Relatar soluções tecnológicas desenvolvidas para manter o ensino de Odontologia;
3. Revisar textos e opiniões sobre a introdução do uso de Inteligência Artificial no ensino de radiologia;
4. Revisar sistematicamente o uso de análise radiômica nas alterações patológicas ósseas dos maxilares;
5. Propor o desenvolvimento de um protótipo de aplicativo de celular capaz de simular o atendimento ambulatorial em odontologia, com finalidade educacional, e também habilitado a realizar teleatendimento odontológico de pacientes reais.

1.4 Metodologia

No contexto educacional, foram realizados um trabalho de entrevista com residentes de odontologia em um hospital público do Distrito Federal, a fim de avaliar o impacto das mudanças no curso de pós-graduação em cirurgia buco-maxilo-facial, e uma revisão sistemática sobre o panorama do ensino de odontologia durante o início da pandemia aliado aos recursos tecnológicos utilizados para a manutenção do ensino. Com um olhar mais profundo sobre as perspectivas futuras, foi produzida uma revisão de texto e opinião sobre os desafios e as vantagens da inserção de inteligência artificial no ensino de radiologia.

Em uma ótica voltada para novos recursos tecnológicos, essa tese contempla ainda uma revisão sistemática focada no uso de análise radiômica (nova tecnologia utilizada no diagnóstico por imagem baseada em inteligência artificial) em alterações ósseas dos maxilares.

Por fim, visando contemplar os desafios deixados pela pandemia em ambos os cenários educacional e de assistência em saúde, foi realizado um trabalho que reporta o desenvolvimento de um protótipo de aplicativo de celular com a finalidade de ajudar alunos e pacientes remotamente.

Como coautora, uma *overview* foi desenvolvida para verificar o desempenho do uso de inteligência artificial para identificação precoce e diagnóstico de tumores malignos quando comparado ao método convencional de avaliação de exames de imagem.

Já no contexto da teleassistência, foi desenvolvida uma revisão integrativa que versa sobre o papel da teleodontologia no atendimento de pacientes com câncer oral durante a pandemia e uma revisão sistemática sobre a satisfação, aderência e qualidade de vida de pacientes com câncer de cabeça e pescoço ao utilizar ferramentas de assistência odontológica à distância. Os aspectos relacionados à teleodontologia na assistência a pacientes são aqui citados devido à produção científica, no entanto, esse tema é detalhadamente desenvolvido em outra tese.

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CAPÍTULO 2

IMPACT OF COVID-19 IN RESIDENCY IN ORAL AND MAXILLOFACIAL SURGERY OF THE FEDERAL DISTRICT PUBLIC HEALTH SYSTEM

Título: Impacto da COVID-19 na educação odontológica: uma pesquisa na residência em cirurgia buco-maxilo-facial da Secretaria de Saúde do Distrito Federal.

Título: Impacto del COVID-19 en la educación odontológica: investigación en la residencia en cirugía oral e maxilofacial de la Secretaría de Salud del Distrito Federal.

Title: Impact of COVID-19 in dental education: a research in residency in oral and maxillofacial surgery of the Federal District Public Health System.

Glaucia Nize Martins Santos*, PhD Student - Base Hospital Institute of the Federal District/ Dentistry Department, Faculty of Health Science, University of Brasilia, Brasilia, Brazil. E-mail: nize.gal@gmail.com
Helbert Eustáquio Cardoso da Silva, PhD Student, - Dentistry Department, Faculty of Health Science, University of Brasilia, Brasilia, Brazil. E-mail: helbertcardososilva@gmail.com
Hugo César Pinto Caracas, PhD, Professor of Orthodontics at the Base Hospital Institute of the Federal District, Brasilia, Brazil. E-mail: caracashugo@hotmail.com
Nilce de Santos Melo, PhD – Professor of Stomatology, Dentistry Department, Faculty of Health Science, University of Brasilia, Brasilia, Brazil. E-mail: nilce@unb.br

*Corresponding author:
Glaucia Nize Martins Santos
Tel: + 55 61 99113-8119 nize.gal@gmail.com

Resumo

Com o isolamento social decorrente da pandemia de coronavírus, a residência em cirurgia buco-maxilo-facial da Secretaria de Saúde do Distrito Federal se adaptou para manter o atendimento e o cronograma do curso. Aulas teóricas migraram para online e houve abrupta mudança das atividades práticas, como a diminuição do atendimento eletivo e novos protocolos de paramentação e desinfecção dos consultórios. O objetivo dessa pesquisa foi entender o impacto da pandemia no ensino dos residentes, incluindo a análise de percepção e do nível de satisfação dos participantes quanto às aulas online e atividades práticas, análise do número e tipo de

cirurgias realizadas em 2020 e atitudes dos alunos voltadas para carreira profissional, por meio de questionários Likert. Apenas metade dos preceptores e menos da metade dos alunos estavam motivados a usar o ambiente virtual de ensino. Ainda, cirurgias foram reduzidas em mais de 40%. Além disso, metade dos residentes responderam que não são capazes de resolver eventos inesperados relacionados à sua formação e que não estão seguros em tomar decisões relativas à sua carreira profissional. A COVID-19 continuará a ter maior impacto na prática cirúrgica, por isso, hospitais devem desenvolver um plano de contingência detalhado, inclusive para o caso de futuras pandemias e escolas devem incorporar opções de educação a distância permanentemente em seu currículo. No serviço descrito, a equipe de preceptores está requerendo a repetição do ano letivo.

PALAVRAS-CHAVE: Educação; Odontologia; Cirurgia Bucal; COVID-19; Doença pelo Novo Coronavírus (2019-nCov)

Resumen

Con el aislamiento social derivado de la pandemia de coronavirus, la residencia en cirugía oral y maxilofacial de la Secretaría de Salud del Distrito Federal se adaptó para mantener la asistencia e el calendario del curso. Las clases teóricas migraron a las online e hubo un cambio brusco en las actividades prácticas, como la reducción de los cuidados electivos y nuevos protocolos de vestimenta y desinfección de las oficinas. El objetivo de esta investigación fue comprender el impacto de la pandemia en la educación de los residentes, incluyendo el análisis de la percepción y el nivel de satisfacción de los participantes con respecto a las clases y actividades practicas online, el análisis del número y tipo de cirugías realizadas en 2020 y las actitudes de los estudiantes dirigidas para la carrera profesional, a través de cuestionarios Likert. Solo la mitad de los tutores y menos de la mitad de los estudiantes estaban motivados para utilizar el ambiente de enseñanza virtual. También, las cirugías se redujeron en más de un 40%. Además, la mitad de los residentes respondieron que no son capaces de resolver imprevistos relacionados con su formación y que no sienten seguros para tomar decisiones sobre su carrera profesional. COVID-19 seguirá teniendo un mayor impacto en la práctica quirúrgica, por lo que los hospitales deben desarrollar un plan de contingencia detallado, incluso para futuras pandemias, y las escuelas deben incorporar permanentemente opciones de educación a distancia en su plan de estudios.

PALABRAS-CLAVE: Educación; Odontología; Cirugía Bucal; COVID-19; Enfermedad por el Nuevo Coronavirus (2019-nCov)

Abstract

With the social isolation resulting from the coronavirus pandemic, the residency in oral and maxillofacial surgery of the Federal District Public Health System adapted to maintain the attendance and course schedule. Theoretical classes migrated to online and there was an abrupt change in practical activities, such as the reduction in elective care and new protocols for dressing and disinfecting the offices. The objective of this research was to understand the impact of the pandemic on the education of residents, including the analysis of perception and the level of satisfaction of the participants regarding online classes and practical activities, analysis of the number and type of surgeries performed in 2020 and student attitudes aimed for professional career, through Likert questionnaires. Only half of the tutors and less than half of the students were motivated to use the virtual teaching environment. In addition, surgeries were reduced by more than 40%. In addition, half of the residents responded that they are not able to resolve unexpected events related to their training and that they are not confident in making

decisions regarding their professional career. COVID-19 will continue to have a greater impact on surgical practice, so hospitals should develop a detailed contingency plan, including for pandemics and schools should permanently incorporate distance education options in their curriculum.

KEYWORDS: Education; Dentistry; Surgery, Oral; COVID-19; 2019-novel coronavirus (2019-nCoV) Infection

INTRODUCTION

The SARS-CoV-2 pandemic was officially acknowledged by World Health Organization in March 11, 2020[1]. Since then, it was determined the total closure of non-essential activities and social isolation by the government of the Federal District, Brazil, and surroundings[2].

It is a consensus that the dental category is unmatched exposed to coronavirus due to its performance in contact with potentially contaminated secretions. Therefore, most dental offices closed during the beginning of the pandemic. Specially, oral and maxillofacial surgeons were exposed, since many of them provide service in the emergency room of hospitals[3].

The Public Health System provides nowadays the only oral and maxillofacial residency program in Federal District, a county of Brazil which counts with more than three million inhabitants. This residency was founded in 2005 and rotates in different public hospitals with tertiary level of care, including outpatient and emergency cares, with emphasis in facial traumatology. At that time, the program was composed by nine residents and five specialist preceptors.

The pandemic and quarantine determined impacts in the residency activities both in the educational aspect and in the clinical care[4]. Face-to-face classes were replaced by online classes and the number of elective surgeries decreased. In addition, patients screening, team dressing and surgical rooms were also adapted, so that the health of professionals and patients could be preserved[5].

Therefore, the aim of this study is to understand the impact of COVID-19 pandemic in teaching residency in oral and maxillofacial surgery, including staffs' and residents' perceptions and level of satisfaction with theoretical online classes and practical activities, and analysis of the number and type of surgical procedures carried out in 2020 compared to the same period last year, and students' attitudes towards their career.

METHODS

This study was approved by the ethics committee of the Base Hospital Institute of the Federal District under the number CAAE 38482620.6.0000.8153.

In order to verify if the changes in the methodologic teaching during quarantine were positive and if they should be turned permanent, an observational prospective cross-sectional study was designed. After assignment of the consent term, validated Likert questionnaires adapted from Holanda[6] were answered via Google Forms, from November to December 2020, by three preceptors and nine students covering the following aspects: a) assessment of online classes, regarding interaction and stimuli; b) attitudes, that is, interest and motivation to teach/ learn; c) dedication, discipline and time management to online education. Furthermore, a self-efficacy validated Likert survey based on Bandura's work[7] and proposed by Polydoro[8] was provided to the students in order to evaluate their attitudes towards organization and execution actions required to achieve a goal.

To each of the criteria mentioned above a concept was applied: 1- Very suitable; 2- Suitable; 3- Indifferent; 4- Poorly suitable; 5- Unsuitable. To assess the average and the standard deviation of the concepts, the following values were assigned: 1 to concept 1; 0,75 to concept 2; 0,50 to concept 3; 0,25 to concept 4; and 0 to concept 5.

Moreover, information describing the number and type of surgical procedures was retrieved from March to July 2019 and compared with the same period of 2020.

RESULTS

In March 2020, institutional policies from the regulatory education board was sent to all residency programs with the following recommendations: theoretical classes must shift to online method, all scientific events should be suspended, knowledge and constant updates about coronavirus disease should be available in online classes, staff over 60 years or staff and students with any risk factor should be taken away from their activities. Since then, four out five preceptors started online theoretical classes to nine oral and maxillofacial students. The students group consisted of six men and three women, with an average age of 22 years old, and average graduation completion time of two years. The staff was composed by three men, with average age of 44 years old. Additional recommendations consisted of emphasis on the new protocols for dressing and de-dressing, as well as the risk classification of emergency room patients.

Since April, 2020, the biggest hospitals of the Federal District were totally dedicated to COVID-19 patients. Although students kept on rotating, elective surgeries were suspended and the main care was focused to inpatients and emergency patients. Also, a high number of contaminated people came from the penitentiaries, where the coronavirus disease rapidly disseminated.

Although all the protocols were strictly followed, three of four preceptors and seven of nine residents were soon contaminated. The first COVID-19 outbreak in Brasília was in May 20, 2020, with 5,161 new cases only that day[9]. Due to it and the dissatisfaction with the online method, mainly by students, in a month and half online classes were shifted to face-to-face classes again. Unfortunately, classes were taken only by three preceptors because one of them was hospitalized for a long time due to coronavirus disease, and shortly after his recovery, he committed self-extermination.

Three main online platforms were used: Zoom™, Google Meet and Microsoft Teams. Most teachers and residents agreed that the access to online platforms was easy, and that the virtual environment proposed learning situations. Students and preceptors also agreed that complementary activities on the content, such as online texts and webinars were useful. Moreover, most students seemed to access classes with the proposed regularity and were satisfied, as well as staff, with the use of e-mail, chat, forum or phone call to answer questions about the content. In addition, only half of the preceptors and less than half of the students were motivated to use the virtual learning environment although most of the teachers judged their ability to teach using online platforms suitable. Almost all preceptors asserted that they have very suitable time organization for online course activities while less than half of the students could not organize their time properly.

The practical activities maintained the same schedule as last year, however, less complex procedures were done in the same period of 2020, which hindered professional training. It was observed that no orthognatic surgery was done during March to August, 2020, and there was a significant increase in the amount of abscess drainage while the amount of mandible fractures surgery decreased. The total of surgical procedures had a decrease of more than 40%. According to the questionnaires, half of the residents were satisfied with the workload of practical activities although most of them judged that the practical activities carried out during the pandemic were insufficient for their professional training. In comparison, all preceptors thought that the workload for practical activities was suitable and only half of them agreed that the practical activities during the pandemic were harmed.

Tables 1 and 2 show detailed students and staff perceptions of online classes and satisfaction with practical activities, respectively. Table 3 shows a comparison of the procedures done in 2019 and in the same period of 2020.

Table 1 – Students perception of online classes and satisfaction with practical activities.

Interaction and Stimulus	**Average**	**SD***
a. Does the virtual environment facilitate interaction and interest in the subject?	0.305	0.166
b. Does the virtual environment propose learning situations?	0.472	0.291
c. Are online activities relevant and meet the proposed objectives?	0.444	0.300
d. Was access to online platforms easy?	0.527	0.458
e. Does the online tool instigate change in behavior and attitude?	0.444	0.370
Interest and motivation		
f. Are you motivated to use the virtual learning environment?	0.361	0.253
g. Was carrying out complementary activities on the content (video, lectures by other teachers, scientific articles, webinars) useful?	0.472	0.317
h. How do you judge your ability to study using the virtual learning environment?	0.444	0.300
Dedication, discipline and time management		
i. How do you judge your time organization for online course activities?	0.416	0.279
j. How do you judge your self- discipline for online teaching?	0.388	0.220
k. Do you access classes with the proposed regularity?	0.666	0.176
Communication tools		
l. Does the environment trigger the exchange of information with colleagues and teachers?	0.305	0.300
m.Are the links provided relevant to the content for learning?	0.416	0.414
n. How do you judge the use of e-mail, chat, forum or phone call to answer questions about the content?	0.472	0.363
Satisfaction with the practical activities of the residency		
o. How do you judge the workload for practical activities in oral and maxillofacial surgery?	0.5	0.484

p. How do you judge the practical activities carried out during the pandemic for your professional training?	0.361	0.397

Statistics based on nine residents' responses. *SD = Standard Deviation

Table 2- Staffs perception of online classes and satisfaction with practical activities.

Interaction and Stimulus	**Average**	**SD***
a. Does the virtual environment facilitate interaction and interest in the subject?	0.416	0.381
b. Does the virtual environment propose learning situations?	0.583	0.520
c. Are online activities relevant and meet the proposed objectives?	0.666	0.577
d. Was access to online platforms easy?	0.833	0.144
e. Does the online tool instigate change in behavior and attitude?	0.416	0.381
Interest and motivation		
f. Are you motivated to use the virtual learning environment?	0.5	0.433
g. Was carrying out complementary activities on the content (video, lectures by other teachers, scientific articles, webinars) useful?	0.583	0.520
h. How do you judge your ability to teach using the virtual learning environment?	0.666	0.577
Dedication, discipline and time management		
i. How do you judge your time organization for online course activities?	0.916	0.144
Communication tools		
j. Does the environment trigger the exchange of information with the students?	0.583	0.520
k. How do you judge the use of e-mail, chat, forum or phone call to answer questions about the content?	0.5	0.5
Satisfaction with the practical activities of the residency		
l. How do you judge the workload for practical activities in oral and maxillofacial surgery?	1	0
m. How do you judge the practical activities carried out during the pandemic for the professional training of residents?	0.5	0.433

Statistics based on three preceptors' responses. *SD = Standard Deviation

Table 3 – Comparison of procedures, 2019 – 2020 years.

March – Aug, 2019		**March – Aug, 2020**	
Elective surgeries:		*Elective surgeries:*	
Orthognatic	31%	Mandible fracture	36.6%
CZM and orbit fracture	16.67%	Lesion exeresis	12.2%
Mandible reconstruction	13.1%	CZM and orbit fracture	12.2%
Lesion exeresis	12%	Removal of synthesis materials	7.3%
Mandible fractures	10.7%	Frontal bone fracture	7.3%
Le Fort I	3.6%	Mandible reconstruction	4.9%
Condylectomy	3.6%	Panfacial fractures	4.9%
Discopexy	2.4%	Le Fort I	4.9%
ATM prothesis	1.155%	Le Fort III	2.425%
Le Fort III	1.155%	Condylectomy	2.425%
Foreign body removal	1.155%	Maxila expansion	2.425%
Eminectomy	1.155%		
Non-specified	1.155%		
Total	**84**	**Total**	**41**
Emergency surgeries		*Emergency surgeries*	

Mandible fracture	80.3%	Mandible fractures	57.45%
Abscess drainage	6.06%	Abscess drainage	31.9%
CZM fracture	4.54%	CZM fracture	6.4%
Face and mouth suture	3.03%	Removal of synthesis materials	2.125%
Panfacial fractures	3.03%	Panfacial fractures	2.125%
Maxila fracture	1.52%		
Palate debridement	1.52%		
Total	**66**	**Total**	**47**

Table 4 – Students' self-efficacy survey.

ACADEMIC SELF-EFFICACY how much I am capable of…	Average	SD*
1. learn the content that is necessary for my training?	0.527	0.422
2. use cognitive strategies (making summaries, spreadsheets, diagrams) to facilitate my learning?	0.472	0.384
3. demonstrate, during the assessment, what I learned during my course?	0.527	0.317
4. understand my course requirements?	0.583	0.414
5. apply the knowledge learned in the course in practical situations?	0.611	0.416
6. establish conditions for the development of the work requested by the course?	0.555	0.390
7. understand the content covered in the course?	0.5	0.375
8. meet the performance required to pass the course?	0.555	0.370
9. prepare for the assessments?	0.527	0.291
SELF-EFFICACY IN REGULATING TRAINING		
10. plan actions to achieve my professional goals?	0.583	0.353
11. reflect on the achievement of my training goals?	0.583	0.306
12. select, among the resources offered by the institution, the most appropriate for my training?	0.5	0.330
13. make decisions related to my training?	0.472	0.422
14. define, with certainty, what I intend to follow among the various possibilities of professional activity that exist in my area of training?	0.388	0.397
15. establish my professional goals?	0.416	0.395
16. solve unexpected problems related to my training?	0.5	0.330
SELF-EFFICACY IN PROACTIVE ACTIONS		
17. keep me updated on new professional trends in my training area?	0.555	0.325
18. seek help from teachers for the development of course activities?	0.444	0.390
19. contribute ideas to improve my course?	0.555	0.273
20. update the knowledge acquired in the course?	0.527	0.363
21. seize opportunities to participate in extracurricular activities?	0.5	0.375

22. seek information about the resources or programs offered by my institution?	0.444	0.273
23. claim extracurricular activities relevant to my training?	0.555	0.325
24. express my opinion when another classmate disagrees with me?	0.555	0.300
25. ask for help, when necessary, from colleagues in the course activities?	0.611	0.377
26. work in a group?	0.527	0.341
27. cooperate with colleagues in course activities?	0.611	0.356
28. establish good relationship with my teachers?	0.666	0.395
29. ask when I am in doubt?	0.611	0.333
30. establish friendships with classmates?	0.666	0.353
31. strieve for academic activities?	0.694	0.370
32. motivate me to do the activities related to the course?	0.694	0.300
33. finish course work on time?	0.5	0.375
34. plan to carry out the activities requested by the course?	0.611	0.333

Statistics based on nine residents' responses. *SD = Standard Deviation

The self-efficacy survey showed that residents were not safe to make decisions related to their academic training and still had doubts about which area to pursue. In addition, most of them had difficulties in use cognitive strategies to facilitate learning while half of them could not understand the content covered in the course. In pandemic time, half of the participants answered that they could not solve unexpected events related to their training. Less than half of the students sought help from teachers for development of course activities while most of them were able to establish friendships with classmates and ask for help from colleagues. Almost all of the students showed motivation and effort to academic activities although less than half seek information about the resources or programs offered by the institution. Table 4 shows detailed results from the self-efficacy survey.

DISCUSSION

COVID-19 is disrupting routines in hospitals and health schools. As such it is important to record and study the full extent of the changes in education being made in response to this international emergency so as to clarify how to recover from this pandemic[10].

In the theoretical context, presential conferences, congresses and meetings have been cancelled or postponed, further reducing the opportunities for continuous education of trainees. On the other hand, virtual platforms allowed the implementation of online lectures and teaching sessions[11–14]. The curricular reforms undertaken by many academic institutions worldwide in the past decade, mainly promoting flipped- classrooms and active learning, have facilitated an easy transition of face-to-face learning to an entirely online method[12,13,15–18]. However, although the described residency has turned to flipped-classroom for a long time ago, oral and maxillofacial residents did not adapt to the synchronous online classes during pandemic. Even though flipped-classrooms for maxillofacial surgery training have been discussed previously, further research is required regarding virtual learning[19,20]. Other asynchronous modalities of online education described in the literature, such as reports and case discussions, online journal articles, webinars for interdisciplinary learning and videos, were well accepted by the interviewed residents. Technology can be very useful[21] but, for many preceptors and students, it still involves a learning curve. The Remote Emergency Teaching[22] imposed by pandemic made impossible to evaluate and choose between synchronous and asynchronous online teaching and learning, to relay to students distance education protocols, yet still keeping the original plan of content delivery. The success of e-learning depends on the attitudes and interactive teaching styles of the staff, as well as on the experience and attitudes of students with regard to technology[23,24]. In this study, the theoretical content of 2020 year was all completed, with online and face-to-face classes.

The COVID-19 pandemic will continue to have a major impact on surgical practice. The first activity to be suspended under the state of emergency in teaching hospitals were dental students' elective procedures. To postpone direct patient care is the biggest challenge, since it is the key component of the dental curriculum[25]. No virtual sessions can duplicate the close experience with patients and surgery can only be perfected by practicing[14,23,26]. Furthermore, it is unclear whether and when the service will be ready to resume elective surgical cases[27]. There is a possibility that surgical education may hinder and inevitably reduce students' interest in pursuing a surgical career[26]. Indeed, there has been declining interest in surgery among United Kingdom medical students[28], and this pandemic may serve to hasten this trend. The elective cases for benign disease that are mostly affected, are the ones that residents usually performed with minimal supervision, in contrast to the more complex urgent or life-threatening operations that are mostly performed by staff.[29] The residents were most concerned with losing experience in the areas of anesthesia, orthognathic surgery, and reconstructive and cosmetic surgery[30], what is in agreement with the findings of this study. Implementing technology into health education may allow students to develop collaborative skills and improve adaptability. Use of tele-technology as well as augmented reality, whereby students can witness live proctoring by surgeons and interact remotely, can help surgical training with an immersive experience[10,14,26,31].

Although still in learning period, residents must correlate their academic training with their valuable contribution to the current health crisis. Students who are better able to adapt to this adverse event usually show more creativity and innovation to alter pre-conceived notions of how patient care should be practiced. In fact, residents can show new methods for developing their skills, teamwork and dedication to research. Regardless of the nuances of each student's situation, all of them will face difficulties due to the widespread effects of the COVID-19 pandemic[10].

CONCLUSION

Moving forward, it will be important to systematically study the effects of the changes on both residents and program training, including residents career progression, health and safety of the team. The lessons learned and changes implemented are likely to forever change the clinical practices[10,27]. Hospitals should focus on re-evaluating and reprioritizing their policies and protocols and include a detailed contingency plan in case of future pandemics. Dental schools should re-evaluate their competency-based education, incorporate variations of distance learning permanently in their curricula, invest in haptic technology to improve psychomotor skills and also in staff training for teaching through technology[23]. In the service described in this article, staff are pleading for the repetition of the residents' school year.

In conclusion, at the time of submission, 7,318,821 cases of COVID-19 in Brazil with 188,259 deaths and 78,320,614 cases around the world with 1,723,502 deaths had been reported[32].

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CAPÍTULO 3

THE SCOPE OF DENTAL EDUCATION DURING COVID-19 PANDEMIC: A SYSTEMATIC REVIEW

Short title: Dental education during COVID-19: A Systematic Review.

Type of manuscript: Systematic Review.

Authors:
Glaucia N M Santos*, DDs, Msc
Helbert E C da Silva, DDs, Msc
André F Leite, DDs, Msc, PhD
Paulo T S Figueiredo, DDs, Msc, PhD
Carla R M Mesquita, DDs, Msc, PhD
Cristine M Stefani, DDs, Msc, PhD
Nilce S Melo, DDs, Msc, PhD

Affiliation:
Glaucia N M Santos and Helbert E C da Silva are doctoral students of the Department of Dentistry, Health Sciences Faculty, University of Brasília, Brasília, Brazil.
André F Leite, Carla R M Mesquita, Paulo T S Figueiredo, Cristine M Stefani and Nilce S Melo are Professors of the Department of Dentistry, Health Sciences Faculty, University of Brasília, Brasília, Brazil.

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*Corresponding author:
Glaucia Nize Martins Santos
Tel: + 55 61 99113-8119 nize.gal@gmail.com

ABSTRACT

INTRODUCTION: COVID-19 forced e-learning processes to develop abruptly and posed challenges to the educational infrastructure. Emergency Remote Teaching was designated to distinguish the new educational scheme. This concept involves production of online activities that may return to face-to-face format as soon as the isolation period ends.

OBJECTIVE: From March through September of 2020, this systematic review attempted to elucidate experiences, benefits and challenges enforced in dental education due to the pandemic, the learning technologies and methods used to maintain education.

METHODS: A literature search was conducted on Cochrane, Embase, Lilacs, Livivo, PubMed, Scopus and Web of Science databases. Grey literature was also contemplated. Studies in which online teaching methods were described and dental learners were the subjects during pandemic were included.

RESULTS: Learning technology, pedagogical model, knowledge gain and dental learners' satisfaction and attitudes towards remote learning were assessed. The JBI Critical Appraisal Checklist for Case Reports was applied as the methodological quality assessment to the sixteen included studies. Assessments were related to demographic and historical characteristics of the participants, the intervention procedure, pre and post-intervention descriptions, and identification of unanticipated events. All studies described the use of learning technology to ensure education continuity, fifteen studies highlighted the pedagogical model applied. Eight studies investigated knowledge gain while twelve searched the learners' satisfaction with online technologies.

CONCLUSION: The evidence suggests that learning technologies can support continuity in dental education. Reported problems include poor knowledge of faculty members on how to deal with technology, Internet connection and content transition to online education.

KEYWORDS: Coronavirus, COVID-19, dental education, dentistry, e-learning, emergency remote teaching, systematic review.

INTRODUCTION

In December 2019, a novel type of pneumonia was reported in Wuhan, China. The viral agent was identified as a beta coronavirus, and the respective infection was named as "Coronavirus Disease 2019 (COVID-19)"[1]. The pandemic and subsequent mitigation measures have acquired great proportions and its impact on society has become increasingly significant. With regard to education, more that 990 million learners in all levels have been affected, which corresponds to 56,6% of total enrolled learners of the world[2].

Unlike many other careers, dentistry is a fusion of three educational components: theory, laboratory, and clinical practice. During the COVID-19 pandemic, dentists were classified in the very-high-risk category because of the potential of exposure to coronavirus through aerosol-generating procedures[3]. Despite the fact that a number of online dental academic programs were available, this pandemic forced e-learning processes to develop abruptly and posed unprecedented challenges to the dental educational infrastructure.

Online learning is used as an alternative to keep learners engaged in order to minimize the consequences of social isolation policies on academic activities[4,5]. Technologies such as virtual reality simulators and augmented reality, which are tools for training learners through interaction with a total or partially three-dimensional environment, have facilitated the introduction of these strategies in some dental schools, especially for pre-clinical disciplines[6,7].

Hence, the term Emergency Remote Teaching (ERT) was designated to distinguish new educational activities during the pandemic from distance education that already existed in some schools. This concept involves production of totally online activities that may return to face-to-face format as soon as the isolation period ends. Thus, the main objective is not to create a new educational model, but to minimize quarantine effects making content accessible to learners during this time[4,8,9].

In this systematic review, Emergency Remote Teaching experiences were evaluated, including benefits and challenges enforced in dental education due to the pandemic, as well as the learning technologies and educational methods that can ensure continuity in the education of dental learners at any level.

METHODS

Protocol and Registration

This systematic review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist[10]. The protocol was registered in PROSPERO database (University of York) (http://www.crd.york.ac.uk/PROSPERO) under number CRD42020213610.

Study Design

A systematic review that analyzed education in dentistry during the COVID-19 pandemic was performed to answer the question: "Which are the experiences, benefits and concerns with dental education during the COVID-19 pandemic?"

Eligibility Criteria

Inclusion criteria:

Retained articles were those studies whose objective was to evaluate any method of remote education during COVID-19 pandemic, for dental learners at any level.

Exclusion criteria:

The following exclusion criteria were applied:

1. Reviews, editorials, letters, personal opinions, book chapters and conference abstracts;

2. Studies in which no online curricular teaching method was described;
3. Studies in which dental learners were not the participants;
4. Studies in which the main objective was to describe learners' perceptions and anxiety about remote education without clearly describe the adopted intervention;
5. Data collected before COVID-19 pandemic;
6. Studies written in non-Latin alphabets.

Information Sources and Search Strategy

Individual search strategies for each of the following bibliographic databases were developed: Cochrane, Embase, Lilacs, Livivo, PubMed, Scopus and Web of Science. A grey literature search was taken using Google Scholar, ProQuest and Open Grey (Appendix 1). A filter restricting to 2019-2020 years was applied to all databases, except Cochrane Database. The end search date was September 21, 2020 across all databases. Manual searches of reference list of relevant articles and of theses and dissertations were also performed.

All references were managed by reference manager software (Mendeley®, Elsevier) and duplicate hits were removed.

Study Selection

The selection was completed in two phases. In phase one, two reviewers (GNMS, HECS) independently reviewed the titles and abstracts of all identified electronic database citations. Articles that did not meet the inclusion criteria were discarded. In phase two, the same reviewers applied the inclusion criteria to the full text of the articles. Both phases were completed using the Rayyan QCRI website (https://rayyan.qcri.org). The references list of selected studies was critically assessed by both examiners (GNMS, HECS). Any disagreement in first or second phase was resolved by discussion until consensus between the two authors was attained. When a consensus was not reached, a third author (AFL) was involved to make a final decision.

Data Collection Process and Data Items

One author (GNMS) collected the required data from the selected articles. A second author (HECS) cross-checked all the collected information. Again, any disagreement was resolved by consensus or the third author (AFL) decision. For each of the included studies, items recorded were: author, year of publication, country, educational institution, learning technology, subjects, pedagogical model, main results and conclusions. If the required data were not complete, attempts were made to contact the authors to retrieve any pertinent missing information.

Methodological quality assessment of included studies

The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case Reports was adapted and applied as the methodological quality assessment[12]. Regarding JBI quality appraisal, two reviewers (GNMS and HECS) scored eight items as Yes, No, Unclear and Not Applicable for sixteen included articles. Any disagreement was resolved by consensus or a third author (AFL) decision.

Outcomes of Interest

Included manuscripts were synthesized in a qualitative and quantitative description focused on two major axes, "the learning technology" and "the pedagogical model", and two minor axes, "knowledge gain" and "dental learners' satisfaction and attitudes towards remote learning".

Synthesis of results

A meta-analysis was planned since the data from the included studies were considered relatively homogeneous.

RESULTS

Study Selection

In phase one, 754 studies were retrieved from the seven electronic databases. In addition, 100 studies were retrieved from Google Scholar and three from ProQuest. No additional study was found across Open Grey. Afterwards, duplicate articles were removed, resulting in 649 remaining different studies. Then, a comprehensive evaluation of the abstracts was conducted and 618 articles excluded from databases. No additional articles were identified from the reference lists of these studies, resulting in thirty-one studies at the end of phase one. Therefore, thirty-one manuscripts were elected to conduct a full-text review and later fifteen studies were excluded (Appendix 2). Finally, sixteen studies were selected for inclusion per study parameters (Figure 1).

Study Characteristics

The sixteen included studies were published in three different types of journals: dental sciences[13,14], multidisciplinary scientific publications[15,16] and educational publications[17–28]. The studies were conducted in nine different countries: Brazil[15], Canada[28], China[16], Costa Rica[13], France[17], Nepal[14], Peru[18], Serbia[24] and United States[19–23,25–27]. Fifteen studies were published in English and one in Portuguese[15]. Sample size ranged from ten[17] to 450[13] participants. A summary of the study descriptive characteristics can be found in Table 1.

Methodological Quality Assessment of Included Studies

All sixteen selected studies were experience reports. Due to the similarity of text structure to case reports, they were evaluated by using JBI Critical Appraisal Checklist for Case Reports[12], with checklist adapted to the educational context. The methodological assessment ranges from low quality: one to three "yes" answers; moderate quality: four to six "yes" answers or high quality: seven or eight "yes" answers.

Thirteen studies[13,14,16–22,24–26-26] presented moderate methodological quality while three studies[15,23,28] showed high methodological quality.

All studies clearly reported the educational situation of the learners during the pandemic period and provided takeaway lessons. However, some selected studies presented methodological problems related to learners' assessment methods (pre-intervention), learning technology, or learning model application and unexpected events. Only two studies clearly described demographic and social learners' characteristics[13,14]. In one study, learner population's history was missing[17] and in another, the post-intervention outcomes were not described[13]. More information about methodological assessment may be found in Table 2.

Results

In order to answer the main question of this systematic review, the following outcomes of interest were considered:

1. <u>Major axes</u>

1.1 The learning technology

Six studies reported the development of a new learning technology and its exclusive use[13,16,18,19,21,28]. Six articles described the use of commercially available platforms[14,15,20,23,25,26] while four studies combined new-developed tools with preexistent technology[17,22,24,27]. Most of the adopted technologies had both computer and mobile phone interfaces. However, two programs had a mobile-only interface[22,24].

In addition to general dentistry, specific theoretical themes were addressed: oral histology[15], oral histopathology[16], dental caries diagnosis[18], dentistry[21], traumatic dental injuries[24], geriatric and special needs dentistry[26] and pediatric dentistry[20,28].

The application of learning technology in laboratory activities was described in four studies[15–17,22]. Virtual microscopy has opened a new digital model of oral histology and histopathology practical learning in which conventional stained slices were scanned, and microscope images were shared over computer networks[15,16]. To improve motor skills in restorative dentistry and prosthodontics, a simulator that includes a micromotor was distributed to learners to perform hands-on training at home with the aid of videoconferences[17]. To allow learners to experience a step-by-step periodontal procedure, a virtual reality mobile application was demonstrated in one study[22].

In addition, some studies aimed to replicate a clinical care scenario. Three of these studies provided online clinical cases so learners could develop diagnostic skills and treatment plans.[13,23,26] Also, one study provided virtual meetings between learners and simulated patients (actors), simulating clinical interaction[19].

1.2 The pedagogical model

While seven studies described exclusively synchronous activities[14,17,20–23,28], four articles reported asynchronous learning[16,18,24,26]. Both modalities were presented in four studies[13,15,19,27]. One study did not describe the online modality of education[25]. Six studies stated that live online computer tutors were available to answer questions regarding the use of the technological tools[13,15,16,23,25,27]. The synchronous online classes ranged from thirty[13] to 120[28] minutes. Four studies developed online classes in small groups[21–23,28] between six[28] and twenty[22] learners and rotation (polling) was applied in two of these experiences[22,23].

Flipped-classroom and blended-learning were also reported[15,28]. Individual activities were described in eight studies[14–17,19,24,26,27].

2. Minor axes

2.1 Knowledge gain

The quantity of knowledge gain was investigated in eight studies. Quizzes[15,20], practical and theoretical tests[15,16], electronic multiple-choice questions and writing tests[25], pre and post-test[18,22] and examinations based on the clinical cases given[23,26] were applied.

Two studies[22,23] described tests application via Zoom™ (https://zoom.us/). Moodle™ (moodle.org) and Google Meet™ (https://meet.google.com/) were also used in theoretical and practical tests[15]. A remote proctoring solution integrated with lockdown browser (http://www.emedley.com/eproctor/) was used in one study[25], the application of multiple-choice quiz questions during and following the presentation in Mentimeter AB website (www.mentimeter.com) was described in one manuscript[20] and one article showed synchronous tests performed in Kahoot!© (kahoot.com) website[15].

Regarding the synchronous tests using Kahoot!©, the authors reported that more than 80% of the learners had a satisfactory or very satisfactory performance[15]. Another author described the percentage of Online group total theoretical test scores was significantly higher when compared to the Traditional group and there were no differences in the lab practical test scores between the two groups[16]. A study related that the thirteen dental learners exposed to the technological tool correctly answered 90% of the questions evaluated, in relation to the twelve learners exposed to the virtual synchronous class group who correctly answered 40% of the same questions[18]. In addition, a manuscript reported that in a group of nineteen learners, more than a half correctly answered the questions at the virtual rotation end[22]. Another experience reported that learners accordingly had interpreted some clinical case information and qualified their recommendations[26]. It was described in a study that participants correctly answered 61% of thirteen questions queried during the presentation, and 83% of seven questions following the presentation correctly[20].

Two authors did not describe the tests results[23,25].

2.2 Dental learners' satisfaction and attitudes towards remote learning

Twelve authors queried the learners' satisfaction with the use of online technologies during pandemic period. Nine of them[16–18,20,23–25,27,28] described respondents' opinions as a positive, acceptable and favorable experience.

Learners with twenty months of previous clinical experience felt that the virtual sessions promoted their critical thinking and solidification of concepts learned. However, learners with little time of clinical experience felt that they learned less during the virtual sessions than they did through traditional clinical education[21].

One article described 64% of the learners reported some level of discomfort before teledentistry had been used. Following the exercise, only 23% reported continued discomfort with the idea of leading a teledentistry visit[19].

The overall satisfaction with ERT was good. Most learners' feedback suggested they would prefer a continuation of the model even after the current scheduling restrictions were lifted[28]. Nevertheless, a study has shown that only 27% suggested to continue the online classes even after the pandemic situation comes under control. The same research demonstrated that 77.51% of respondents rated online classes as non-effective. A majority of learners rated the understanding level of online classes as moderate and a total of 58.4% suggested that teachers need training on how to create and give online classes[14].

Risk of Bias Across Studies

The selected studies were all descriptive and used similar methods, which reduced the possibility of misinterpretation. Results were considered homogeneous enough but did not have compatible quantitative data that would allow a meta-analysis.

DISCUSSION

Summary of Evidence

This is the first systematic review that assessed the Emergency Remote Teaching (ERT) experiences during coronavirus social distancing. The sixteen included studies justified the COVID-19 transformation to partially or totally online courses to allow learners to continue learning, faculty to stay engaged in their activities, and the dental school community to remain connected and supportive of each other throughout a quarantine period[21]. ERT has threatened conventional training opportunities but introduced some others, accelerating the reliance and significance of technology for health education[29–31]. Reported problems included faculty members' limited knowledge of technology, availability and strength of learners' Internet connection, and transition of some topics to the online version.

E-learning, known as a kind of distance learning that uses electronic devices to promote learning, has multiple possibilities that can undoubtedly improve education[32,33] and growing evidence shows that it is as effective as traditional methods[34,35]. However, the sudden shift from traditional teaching methods did not allow sufficient time for adaptation. These hurried moves by so many institutions at once could leave the perception of e-learning as a weak option, when in truth the transition under these circumstances will not take full advantage of the affordances and possibilities of the online method. Hence, the term Emergency Remote Teaching (ERT) is defined as a temporary shift of instructional delivery to an alternate mode due to crisis environments[8].

Authors have proposed the CIPP assessment of ERT, which is more focused on the (social) Context, Input (educational context), and Process Evaluations than on the Product (learning) [8,36].

The social context assesses needs, problems, and relevant contextual conditions. Firstly, when isolated due to imposed quarantine and travel restrictions, learners may suffer anxiety at different levels[37,38]. Social distancing brings fear from uncertainty, physical discomfort, loneliness, and stress that negatively affect the teaching-learning process[39,40]. Computer skill level, Internet access, and electronic devices availability were significant factors in facilitating the successful acceptance of e-learning[41–43]. In this context, only two of the included articles, from middle-[13] and low-income countries[14], reported the poor technology infrastructure of the dental learners. Therefore, the challenges of adopting online learning in developing countries remain a reality due to the digital delay when compared to the developed countries[44]. One review study[45], which has put the technological aspects of e-learning readiness[46] (the assessment of how ready an institution is to adopt and implement e-learning) as the main criteria for the success of online system, indicated that 45% of e-learning projects in developing countries are total failures, 40% are partial failures, while only 15% are successful.

The Input (educational context) assesses a strategy program, action plan and staffing arrangements to meet targeted needs and achieve goals. The Zoom™ platform was the preferred platform in seven of the included studies. Zoom™ offers several possibilities, such as synchronous and asynchronous interactions, recording lectures, chats, screen sharing, sending and receiving files, division into small groups or individual activities, and lectures to large audiences. These results are in line with other findings in the literature. In an opinion article, a maxillofacial training during the pandemic highlighted the Zoom™ platform, stressing the importance of audio and visual connection enabling inter-personal contact that reinforces engagement and deeper learning[47]. A systematic review demonstrated presence of each type of interaction, which includes learner–content, learner-learner, and learner–teacher, when meaningfully integrated, increases the learning outcomes[48]. Perceived limitations of the virtual learning strategy were the loss of collegiality and networking. In addition to difficult interactions with trainers in an "artificial" encounter where communication may be personal challenging, technical glitches and the inability to cover all disciplines are all points that need to be taken into account in planning the future dental educational experiences[30]. According to virtualization feasibility of the dental disciplines, one included study showed that only 26% of the dental courses could be totally virtualized with no content changes, while 32% were unfeasible[13].

The Process Evaluations monitor, assess, and report on the implementation of plans. A previous study indicated that less than half of the participants expressed positive perceptions of e-learning[49] while other studies reported health learners found it gratifying[33,50]. According to this systematic review, most of the included articles described respondents' experience as favorable towards ERT and the use of the Zoom™ platform. The main advantage was the availability of dental learners to learn at all times[24,25], along with other health sciences learners[51]. Some included studies noted participants prefer a continuation of the model even after the end of current restrictions[21,23,28]. Reported problems include too short a scheduled time to cover all planned activities[22], technical issues related to pop-up blockers and unstable Internet connectivity[23,27]. Despite the difficulties, many universities recommend the incorporation of an online method in the curricula[15,23].

Product (learning) evaluation consists of identifying and assessing outcomes. Undoubtedly, evaluation had the highest fluctuation in this systematic review. Contrary to what might be supposed, online classes require greater learner responsibility and leadership than passively receiving the content in face-to-face classes[52]. Some strategies to replace the traditional tests were developed, such as the learners participation in online forums[28], self-assessment of videos recorded from previous online activities[19] and discussion of questionnaires in real time[20]. Pre- and post-evaluations may be considered to assess learning outcomes in online education[20].

Conclusions

The CIPP assessment of ERT concluded that, in the social Context, countries with better infrastructure improved the learning process as the technology access was greater, although the learners' levels of anxiety and fear everywhere were similar. The Input (educational context) showed that ease of communication and different types of interactions between learners, teachers and the content are the most important requirements when choosing an online learning platform. The Process Evaluation revealed that the respondents approved ERT and recommended e-learning after the end of the quarantine. The Product (learning) evaluation showed high fluctuation, since different strategies were adopted do assess learners' knowledge gain.

In summary, campuses have been closed due to natural disasters and other unexpected events in recent years. The data showed that most learners appreciated the technology-based system, however they have missed some practical activities. Exploring learners' satisfaction towards e-learning and seeking feedback can help institutions to improve e-learning experience. It is hoped that this sudden shift will not be considered a detriment to education, but a learning experience to open a wide way to technology-based education[51].

Limitations

Overall, the number of studies published on the use of e-learning in dental education during the COVID-19 pandemic are limited and thus contributed to the small number of studies included in this systematic review. Regarding the quality appraisal of the included studies, some methodological quality issues were found related to the learners' demographic and social context, learning technology/ learning method, and description of unwanted events. Also, despite the varied study population groups considered for inclusion in this review, none dental assistant/ hygienist students were evaluated. This warrants the need for more studies in this area as well as diverse study populations. It is also important to consider that the learners' perception of ERT modalities was not thoroughly assessed, although this is of great value when proposing a new educational reality.

CONCLUSION

The experiences showed that the ERT is a good option to ensure multimodal and active education during COVID-19 period, since e-learning is well-received by dental learners. Some benefits are to decrease anxiety and to promote mutual support while in mandated quarantine.

The identified problems include poor technological infrastructure in both learners' and institutions' environment and difficulty in replacing clinical activities.

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Figure 1 - Flow diagram of literature search and selection criteria.

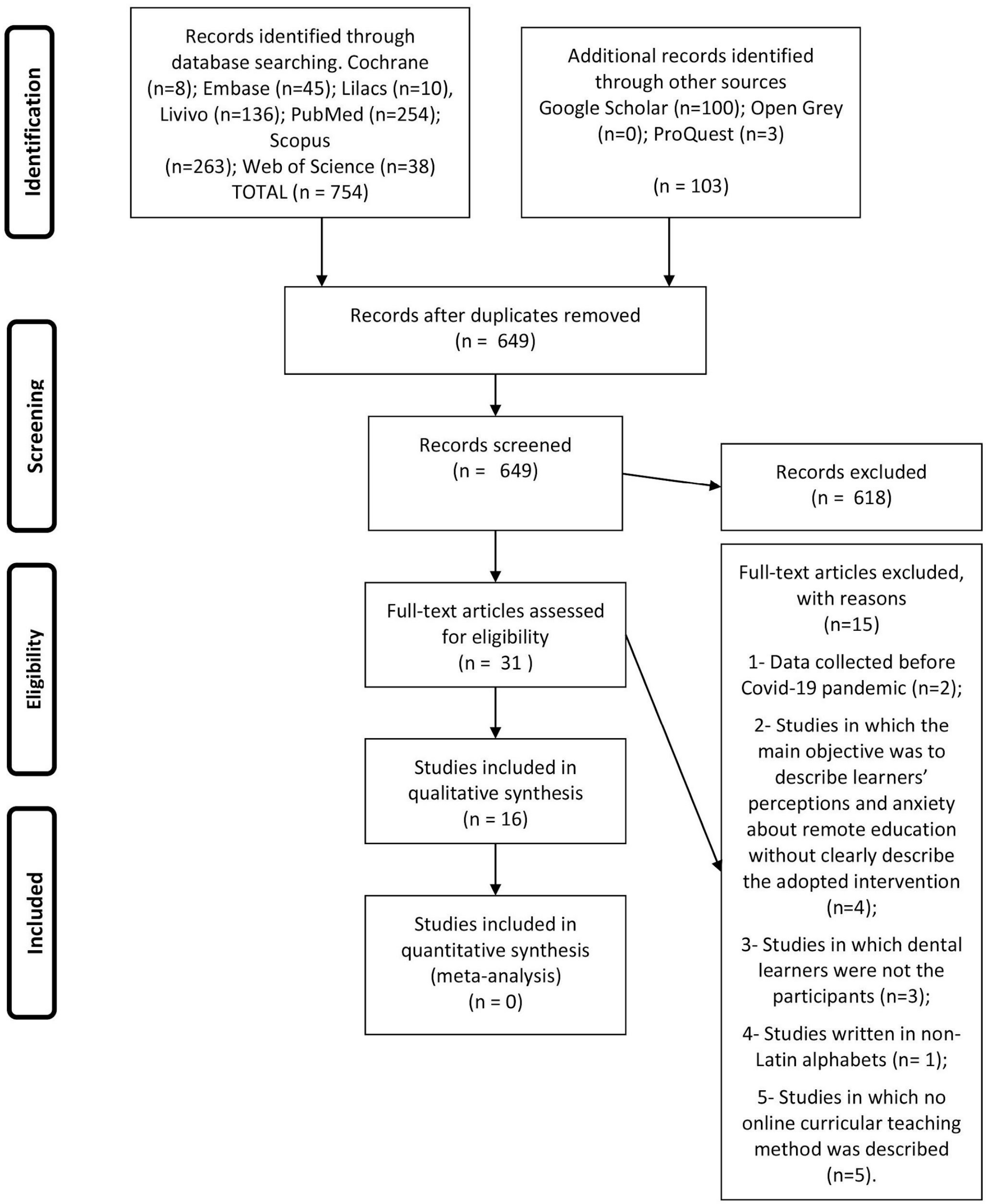

Table 1 - Summary of descriptive characteristics of included studies (n=16).

Author(s)/ Year/ Country/ Institution	Learning Technology	Subjects	Pedagogical Model	Results	Conclusion
Aguilar-Gálvez et al. (2020) Peru University Científica del Sur	Virtual learning object	13 undergraduate dental students	An asynchronous teaching material to learn the diagnosis for dental caries.	VLO group correctly answered 90% of the questions. Virtual synchronous class group correctly answered 40% of the same questions. The opinions about VLO were favorable.	This new virtual proposal application is recommended.
Chavarría-Bolaños et al.(2020) Costa Rica University of Costa Rica	Metics Platform	450 undergraduate dental students	Synchronous and asynchronous meetings with several didactic activities like interdisciplinary seminars, video demonstrations, clinical case discussions, diagnosis and treatment plans of virtual simulated patients. Training in virtual environment was provided.	26% of the courses could be totally virtualized, while 32% were unfeasible. All students had access to a virtual environment using either a laptop, a cell phone, a tablet or a desk computer.	Strategies and changes will be analyzed for reinsertion into the clinical activities Feedback from the students the teachers is essential.
Galibourg et al. (2020) France Paul Sabatier University	Autonomous simulation equipment, including a micromotor and Zoom™	10 undergraduate dental students	Two 30-minute sessions of practical work in restorative dentistry and prosthodontics guided by the live teacher's explanations and videos.	Learning of motor skills, keeping human connection through interaction with teachers and allowing students to spend time practicing, either during remote-training sessions or independently were pointed advantages.	Future work should consider the educational and clinical benefit of this technology and its use post-pandemic.
Gardner et al.(2020) USA University of Texas	Virtual Dental Clinic	35 third-years dental students and 45 fourth-years students.	Small-group learning through synchronous videoconferencing, case presentations and discussion, article reviews, and videos of procedures in dentistry.	Fourth- years students, felt that sessions promoted their critical thinking and solidification of concepts learned earlier. Third-years students felt that they learned less during the sessions than they did through traditional education.	Groups felt that prosthodontics/restorative dentistry, practice management, oral pathology, and general practice should continue online in the future. This allows students to benefit from multimodal learning.
Gyurko et al. (2020) USA Tufts University School of Dental Medicine	Touch Surgery virtual reality mobile application and Zoom™	Predoctoral and postclinical dental learners, divided in groups of about 20.	The mobile application allowed learners to experience a step-by-step periodontal procedure.	The case presentation provided real-life examples for the virtual reality application. The schedule of 60 minutes was too short to cover all planned activities.	Future virtual rotations may include the use of augmented reality and individual learner participation to "perform" the surgical procedures.

			Periodontal synchronous sessions via Zoom™ and presentation of clinical cases by learners. Knowledge retention was assessed by question/ answer pre and post-activity.	Some of the questions could have been answered simultaneously.	Physical participation in actual live periodontal surgeries will still be necessary.
Kakadia et al. (2020) USA Harvard School of Dental Medicine	Zoom™	34 predoctoral dental students.	Students were equally split into two synchronous sessions, in Zoom™ breakout rooms. A clinical case was disseminated to each student session one hour before the class starts. Six minutes were allotted per station for oral examinations based on the clinical case given.	OSCE was similarly successful to traditional OSCE, and all respondents felt they were able to fully showcase their knowledge. Half of the respondents thought that even future OSCEs should be performed online. There were problems related to technical difficulties.	Considering the overall success of the online OSCE and positive feedback from students and examiners/staff, there may be value in moving traditionally in-person assessments online, even post-pandemic.
Mladenovic et al. (2020) Serbia University of Pristina	PowerPoint presentations distributed to students via e-mail or Moodle™ Dent.INJURY APP Mobile application	31 final year undergraduate dental students	Mobile application for studying traumatic dental injury on an online work week. A questionnaire with Likert scale via Google Forms assessed the student's satisfaction with the additional mobile learning.	More than 90% of the students assert that the application has helped them. This type of additional learning has the advantage of being available at all times.	Mobile learning provides a high level of commitment, innovation, personalization and autonomy. The application allowed students to explore content at their own pace, dive deeper into the most interesting topics, and reward their curiosity with instant answers.
Moore et al.(2020) USA University of North Carolina	Zoom™ and Echo360	Doctor of Dental Surgery program	Personnel were asked to provide support to all faculty and students transitioning to online education. Sessions via Zoom™ and Echo360 were provided. eProctor (ExamN, by AllofE in the eMedley suite) was the assessment tool solution.	88% of the students were satisfied or extremely satisfied with the instructors' use of technology 77% were satisfied or extremely satisfied with Zoom™ platform. 67% said that nothing is limiting their ability to participate in online learning activities.	Online classes via Zoom™ and Tests with eProctor tool were well received by the students.
Nair et al. (2020) USA University of Iowa	PowerPoint presentation template with prefilled patient information and additional reading material.	20 final-year undergraduate dental students	A real clinical case and links with additional reading material about the patient's major health condition were sent to students. Students appraised it using the risk of ROHD assessment. This tool consists of a set of 10 open-ended questions, about Geriatric and Special Needs Dentistry.	The students' responses were detailed and reflected in individual decision-making styles. Students subjectively interpreted some case information and qualified their recommendations accordingly.	The unexpected positive result was that application of the ROHD skillset resulted in recommended patient outcomes. Students' self-reported biases helped to provide context for why a particular risk stage and treatment plan was chosen.

			Each assessment took approximately 45 minutes to complete.		
Omar et al. (2020) USA A.T. Still University	Simulation center management solution (CAE Learning Space) was introduced as the Standardized patient encounter platform. Zoom™	60 first-year and 41 second-year undergraduate dental students.	Patients, students, and faculty received previous instructions. The software linked each encounter to a recorded Zoom™ meeting. Recorded encounters enabled the faculty to observe them and to provide feedback. This also enabled the students to revisit their encounters for self-improvement.	Students' feedback was positive and the majority of the encounters were successful. Technical issues related to pop-up blockers and unstable Internet connectivity were experienced.	The incorporation of online Standardized Patient encounters through a Web-based platform represented a useful tool to enhance dental students' communication skills in the preclinical years.
Pani & Vieira (2020) Canada University of Western Ontario	OWL - Online platform	76 undergraduate dental students and two pediatric dentists	Groups of six students were in a two-hour live session. The session was divided into a 15-minute case presentation and selection of simulated clinical exercises, followed by restorative exercises for an 1h30minute, and a 15-minute group discussion of the different techniques chosen. An online forum was set up to allow students to continue the debate online via OWL platform.	Feedback suggested that students would prefer a continuation of the model even after the current restrictions were lifted. For instructors, moving the pre-reading and case scenario online allowed for more focused discussions and better time management.	The integration of an online LMS to clinical and/or pre-clinical exercises may provide a useful solution to maximize contact time in the current pandemic scenario.
Patel et al. (2020) USA University of Texas	The Simulation Team developed a series of synchronous teledentistry encounters using live actors as patients.	93 third-year undergraduate dental students	Students were tasked with two eight-minutes patient encounters in which they provided differential diagnosis and care. Immediate feedback was provided by the faculty. Encounters were recorded and reviewed three weeks after, when students rated their performance.	For the pre-survey, 64% reported some level of discomfort. Following the exercise, 23% reported continued discomfort with the idea of teledentistry.	The survey revealed that comfort level improved. Simulation exercises provided opportunities to teach and test telehealth practices.
Patterson et al. (2020) USA University School of Dentistry, Virginia University of Texas University College of Dentistry, Dallas, Texas	Zoom™ incorporating Microsoft PowerPoint lecture and Mentimeter AB platform.	50 pediatric dental residents	Mentimeter AB enabled multiple-choice quiz questions during the presentation to assess information knowledge and a multiple-choice quiz questions following the presentation to assess information retention. Results of the presentation quiz outcomes were discussed in real-time.	Pediatric dentistry residents reported a positive learning experience. Participants correctly answered 61% of the questions queried during the presentation, and 83% following the presentation.	Response anonymity eliminates intimidation while fostering participation for small groups, whereas for larger programs the data collected assists presenters in restructuring real-time content delivery for improved efficacy. Constructing parallel pre and post-evaluations may enhance relevant learning outcomes.

University of Florida					
Spalding et al. (2020) Brazil Dentistry School of Science and Technology Institute of Paulista State University (ICT-Unesp)	PowerPoint presentation recorded in Zoom™, Moodle™ Platform, Google Meet™, Google Classroom™ and Kahoot!©	86 first-year undergraduate dental students	Video classes were available in Moodle™ or Google classroom prior to flipped classrooms via Google Meet™. Practical histologic microscopy slides were available in Moodle™ and Google Meet™ platforms, as a part of flipped classrooms. The encounters were synchronous, including debates, discussions and clarifications of doubts. Kahoot!© quizzes enabled synchronous tests. Theoretical and practical assessments were done via Moodle™.	More than 80% of the students had satisfactory or very satisfactory performance. More than 50% of the students had an average grade above seven using Kahoot!© quizzes.	Digital tools and teaching platforms will not solve Brazilian educational problems. Changes in the learning and teaching conception and commitment between all people involved in this process are necessary. That is also recommended strategies focused on mental health.
Tuladhar et al. (2020) Nepal Gandaki Medical College	Zoom™ platform	74 undergraduate dental students and 135 undergraduate medical students	Synchronous online classes for the theoretical portion of the curriculum.	77.51% rated online classes as non-effective. The majority of students rated the understanding of online classes as moderate. 58.4% suggested that the teachers need training on how to take online classes; Only 27.30% suggested continuing the online classes after pandemic.	Problems in Internet connectivity due to electricity cut down. Students will need a revision of some of the topics covered during the online classes once they are back to regular traditional classes.
Zhong et al. (2020) China Nanjing Medical University	Online e-Learning platform of Nanjing Medical University Virtual Simulation Experiment Teaching Center for Dentistry	94 third-year undergraduate dental students	Online oral histopathology course plus face-to-face laboratory learning (Online group), compared to previous face-to-face course (Traditional group). Recorded theoretical lessons and scanned conventional stained slices were given through the e-learning platform. There were prompt instructors for each online class.	The total test score of the Online group was significantly higher than that of the Traditional group. There were no differences of the Lab test scores between the groups. Remote learning and virtual microscopy courses were well accepted by students.	Remote learning and virtual technology have a positive impact on oral histopathology and this represents a promising tool for dental education in the future.

VLO, Virtual learning object; OSCE, Online Objective Structured Clinical Examinations; ROHD, Rapid Oral Health Deterioration; CAE, Civil Aviation Education; LMS, Learning management system.

Table 2 – Methodological quality of included studies (adapted from the JBI Critical Appraisal Checklist for Case Reports)

Checklist questions	Aguilar-Gálvez et al. (2020) (18)	Chavarría-Bolaños et al.(2020) (13)	Galibourg et al.(2020) (17)	Gardner et al.(2020) (21)	Gyurko et al. (2020) (22)	Kakadia et al. (2020) (23)	Mladenovic et al. (2020) (24)	Moore et al. (2020) (25)
Were learner population's demographic and social characteristics clearly described?	No	Yes	No	No	No	No	No	No
Was the learner population's history clearly described (considering the analyzed context)?	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Was the current educational situation of the learners on the context clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were assessment methods and the results clearly described (pre-intervention)?	Yes	Yes	No	No	No	Yes	No	Yes
Was the intervention(s) or procedure(s) / resource(s) (learning technology) or (learning model) clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Were the post-intervention outcomes clearly described?	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Were unwanted or unanticipated events identified and described?	No	No	Yes	No	Yes	Yes	No	Yes
Does the experience report provide takeaway lessons?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Methodological Quality*	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**Moderate**	**High**	**Moderate**	**Moderate**

*Low quality: 1 to 3 "yes" answers; Moderate quality: 4 to 6 "yes" answers; High quality: 7 or 8 "yes" answers.

Checklist questions	Nair et al. (2020) (26)	Omar et al. (2020) (27)	Pani & Vieira (2020) (28)	Patel et al. (2020) (19)	Patterson et al. (2020) (20)	Spalding et al. (2020) (15)	Tuladhar et al. (2020) (14)	Zhong et al. (2020) (16)
Were learner population's demographic and social characteristics clearly described?	No	No	No	No	No	No	Yes	No
Was the learner population's history clearly described (considering the analyzed context)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Was the current educational situation of the learners on the context clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were assessment methods and the results clearly described (pre-intervention)?	No	No	Yes	Yes	No	Yes	No	Yes
Was the intervention(s) or procedure(s) / resource(s) (learning technology) or (learning model) clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Were the post-intervention outcomes clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Were unwanted or unanticipated events identified and described?	No	Yes	Yes	No	No	Yes	Yes	No
Does the experience report provide takeaway lessons?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Methodological quality*	**Moderate**	**Moderate**	**High**	**Moderate**	**Moderate**	**High**	**Moderate**	**Moderate**

*Low quality: 1 to 3 “yes” answers; Moderate quality: 4 to 6 “yes” answers; High quality: 7 or 8 “yes” answers.

Appendix 1. Database Search.

Database	Search
Cochrane (Sep 21, 2020)	("severe acute respiratory syndrome" OR "COVID-19" OR "COVID 19" OR "coronavirus" OR "SARS-CoV-2" OR "SARS CoV 2" OR "pandemic" OR "lockdown" OR "Coronavirus Infection" OR "Coronavirus Infections" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "2019 nCoV" OR "social isolation" OR "patient isolation" OR "Social Distance" OR "Social Distances" OR "infection control" OR "human coronavirus" OR "coronaviruses" OR "SARS virus" OR "betacoronavirus") AND ("dentistry" OR "oral medicine" OR "dental" OR "dentistry school" OR "school dentistry" OR "dental school" OR "dental schools" OR "oral medicine school" OR "Dental Specialties" OR " Dental Continuing Education" OR "Graduate Dental Education" OR "oral medicine course" OR "dental course" OR "dentistry course" OR "odontology" OR "dental curricula" OR "oral health" OR "oral health school" OR "oral health course" OR "dentistry curricula" OR "Dental Education" OR "dental undergraduate" OR "dental postgraduate" OR "dental residency" OR "dentistry undergraduate" OR "dentistry undergraduate education" OR "dental undergraduate education" OR "dentistry postgraduate" OR "dental postgraduate course" OR "dentistry residency" OR "oral health residency" OR "oral medicine residency" OR "oral health technician course" OR "dental technician course" OR "Dental Health Education" OR "dental health" OR "Dental Faculty" OR "dental students" OR "dentistry students" OR "oral medicine students" OR "oral health students" OR "dental health students" OR "dental teaching" OR "dental learning" OR "oral medicine teaching" OR "oral medicine learning" OR "dentistry learning" OR "dentistry teaching" OR "dentistry continuing education" OR "oral medicine continuing education" OR "oral health continuing education" OR "dental health continuing education") AND (e-learning OR "elearning" OR "computed-aided learning" OR "computed aided learning" OR "self instruction learning" OR "self-instruction learning" OR "computerized self instruction programs" OR "computerized self-instruction programs" OR "programmed learning" OR "blended learning" OR "Self-instruction Programs" OR "Self instruction Programs" OR "Self-Instruction Program" OR "Self Instruction Program" OR "Self-Instruction Programs" OR "Self Instruction Programs" OR "Programmed Learning" OR "computer assisted learning" OR "computer-assisted learning" OR "web based education" OR "web-based education" OR "computational intelligence" OR "computer vision system" OR "knowledge representation (computer)" OR "computer reasoning" OR "machine learning" OR "machine education" OR "computer based learning" OR "computer-based learning" OR technology OR "computerized programmed instruction" OR "computer assisted instruction" OR "computer-assisted instruction" OR "computerized self instruction program" OR "computerized self-instruction program" OR "online learning" OR "Online Education" OR "Online Educations" OR "computerized assisted instruction" OR "online courseware" OR "web based learning" OR "web-based learning" OR "education technology" OR "distance learning" OR "telemedicine" OR "tele-medicine" OR "tele medicine" OR "teledentistry" OR "tele dentistry" OR "tele-dentistry" OR "teleodontology" OR "tele odontology" OR "tele-odontology" OR "teleassistance" OR "tele assistance" OR "tele-assistance" OR "remote sensing technology" OR "teledental" OR "tele-dental" OR "tele dental" OR "self-instruction" OR "self instruction" OR "online teaching" OR "Dental Informatics" OR "m-learning" OR "mlearning" OR "mobile learning" OR "electronic learning" OR "electronic teaching" OR "social media" OR "mobile app" OR "mobile apps" OR "software" OR "computer program" OR "website" OR "m-health" OR "mhealth" OR "mobile

	health" OR "telehealth" OR "tele-health" OR "tele health" OR "tele-education" OR "tele education" OR "remote learning" OR "remote teaching" OR "remote education" OR "distance education" OR "distance continuing education" OR "remote continuing education")
Embase (Sep 21, 2020)	('severe acute respiratory syndrome' OR 'covid-19' OR 'covid 19' OR 'coronavirus' OR 'sars-cov-2' OR 'sars cov 2' OR 'pandemic' OR 'lockdown' OR 'coronavirus infection' OR 'coronavirus infections' OR 'severe acute respiratory syndrome coronavirus 2' OR '2019-ncov' OR '2019 ncov' OR 'social isolation' OR 'patient isolation' OR 'social distance' OR 'social distances' OR 'infection control' OR 'human coronavirus' OR 'coronaviruses' OR 'sars virus' OR 'betacoronavirus') AND ('dentistry' OR 'oral medicine' OR 'dental' OR 'dentistry school' OR 'school dentistry' OR 'dental school' OR 'dental schools' OR 'oral medicine school' OR 'dental specialties' OR 'continuing dental education' OR 'graduate dental education' OR 'oral medicine course' OR 'dental course' OR 'dentistry course' OR 'odontology' OR 'dental curricula' OR 'oral health' OR 'oral health school' OR 'oral health course' OR 'dentistry curricula' OR 'dental education' OR 'dental undergraduate' OR 'dentistry undergraduate education' OR 'dental undergraduate education' OR 'dental postgraduate' OR 'dental postgraduate course' OR 'dental residency' OR 'dentistry undergraduate' OR 'dentistry postgraduate' OR 'dentistry residency' OR 'oral health residency' OR 'oral medicine residency' OR 'oral health technician course' OR 'dental technician course' OR 'dental health education' OR 'dental health' OR 'dental faculty' OR 'dental students' OR 'dentistry students' OR 'oral medicine students' OR 'oral health students' OR 'dental health students' OR 'dental teaching' OR 'dental learning' OR 'oral medicine teaching' OR 'oral medicine learning' OR 'dentistry learning' OR 'dentistry teaching' OR 'dentistry continuing education' OR 'oral medicine continuing education' OR 'oral health continuing education' OR 'dental health continuing education') AND ('e learning' OR 'elearning' OR 'computed-aided learning' OR 'computed aided learning' OR 'self instruction learning' OR 'self-instruction learning' OR 'computerized self instruction programs' OR 'computerized self-instruction programs' OR 'blended learning' OR 'self-instruction program' OR 'self instruction program' OR 'self-instruction programs' OR 'self instruction programs' OR 'programmed learning' OR 'computer assisted learning' OR 'computer-assisted learning' OR 'web based education' OR 'web-based education' OR 'computational intelligence' OR 'computer vision system' OR 'knowledge representation (computer)' OR 'computer reasoning' OR 'machine learning' OR 'machine education' OR 'computer based learning' OR 'computer-based learning' OR 'technology' OR 'computerized programmed instruction' OR 'computer assisted instruction' OR 'computer-assisted instruction' OR 'computerized self instruction program' OR 'computerized self-instruction program' OR 'online learning' OR 'online education' OR 'online educations' OR 'computerized assisted instruction' OR 'online courseware' OR 'web based learning' OR 'web-based learning' OR 'education technology' OR 'distance learning' OR 'telemedicine' OR 'tele-medicine' OR 'tele medicine' OR 'teledentistry' OR 'tele dentistry' OR 'tele-dentistry' OR 'teleodontology' OR 'tele odontology' OR 'tele-odontology' OR 'teleassistance' OR 'tele assistance' OR 'tele-assistance' OR 'remote sensing technology' OR 'teledental' OR 'tele-dental' OR 'tele dental' OR 'self-instruction' OR 'self instruction' OR 'online teaching' OR 'dental informatics' OR 'm-learning' OR 'mlearning' OR 'mobile learning' OR 'electronic learning' OR 'electronic teaching' OR 'social media' OR 'mobile app' OR 'mobile apps' OR 'software' OR 'computer

	program' OR 'website' OR 'm-health' OR 'mhealth' OR 'mobile health' OR 'telehealth' OR 'tele-health' OR 'tele health' OR 'tele-education' OR 'tele education' OR 'remote learning' OR 'remote teaching' OR 'remote education' OR 'distance education' OR 'distance continuing education' OR 'remote continuing education') AND [2019-2020]/py
Lilacs (Sep 21, 2020)	(tw:(("severe acute respiratory syndrome" OR "COVID-19" OR "COVID 19" "coronavirus" OR "SARS-CoV-2" OR "SARS CoV 2" OR "pandemic" OR "lockdown" OR "Coronavirus Infection" OR "Coronavirus Infections" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "2019 nCoV" OR "social isolation" OR "patient isolation" OR "Social Distance" OR "Social Distances" OR "infection control" OR "human coronavirus" OR "coronaviruses" OR "SARS virus" OR betacoronavirus OR "infecciones por coronavirus" OR "infecções por coronavirus" OR "vírus del SRAS" OR "Vírus da SARS") AND ("dentistry" OR "oral medicine" OR "dental" OR "dentistry school" OR "school dentistry" OR "dental school" OR "dental schools" OR "oral medicine school" OR "Dental Specialties" OR "Continuing Dental Education" OR "Graduate Dental Education" OR "oral medicine course" OR "dental course" OR "dentistry course" OR "odontology" OR "dental curricula" OR "oral health" OR "oral health" OR "oral health school" OR "oral health course" OR "dentistry curricula" OR "dental curricula" OR "Dental Education" OR "dental undergraduate" OR "dental postgraduate" OR "dental residency" OR "dentistry undergraduate" OR "dentistry undergraduate education" OR "dental undergraduate education" OR "dentistry postgraduate" OR "dental postgraduate course" OR "dentistry residency" OR "oral health residency" OR "oral medicine residency" OR "oral health technician course" OR "dental technician course" OR "Dental Health Education" OR "dental health" OR "Dental Faculty" OR "dental students" OR "oral medicine students" OR "oral health students" OR "dental health students" OR "dentistry students" OR "dental teaching" OR "dental learning" OR "oral medicine teaching" OR "oral medicine learning" OR "dentistry learning" OR "dentistry teaching" OR "dental continuing education" OR "dentistry continuing education" OR "oral medicine continuing education" OR "oral health continuing education" OR "dental health continuing education" OR Odontología OR Odontologia OR "Educación en Odontologia" OR "Educação em Odontologia" OR "Educación Continua en Odontología" OR "Educação Continuada em Odontologia" OR "Educación de Posgrado en Odontología" OR "Educação de Pós-Graduação em Odontologia" OR "Docentes de Odontología" OR "Docentes de Odontologia" OR "Facultades de Odontología" OR "Faculdades de Odontologia" OR "Estudiantes de Odontología" OR "Estudantes de Odontologia") AND (e-learning OR "elearning" OR "computed-aided learning" OR "computed aided learning" OR "self instruction learning" OR "self-instruction learning" OR "computerized self instruction programs" OR "computerized self-instruction programs" OR "programmed learning" OR "blended learning" OR "Self-instruction Programs" OR "Self instruction Programs" OR "Self-Instruction Program" OR "Self Instruction Program" OR "Self-Instruction Programs" OR "Self Instruction Programs" OR "Programmed Learning" OR "computer assisted learning" OR "computer-assisted learning" OR "web based education" OR "web-based education" OR "computational intelligence" OR "computer vision system" OR "knowledge representation (computer)" OR "computer reasoning" OR "machine learning" OR "machine education" OR "computer based learning" OR "computer-based learning" OR technology OR "computerized programmed instruction" OR "computer assisted instruction" OR "computer-assisted instruction" OR "computerized self instruction program" OR "computerized self-instruction program" OR "online learning" OR "Online Education" OR "Online Educations" OR "computerized assisted instruction" OR "online courseware" OR "web

	based learning" OR "web-based learning" OR "education technology" OR "distance learning" OR "telemedicine" OR "tele-medicine" OR "tele medicine" OR "teledentistry" OR "tele dentistry" OR "tele-dentistry" OR "teleodontology" OR "tele odontology" OR "tele-odontology" OR "teleassistance" OR "tele assistance" OR "tele-assistance" OR "remote sensing technology" OR "teledental" OR "tele-dental" OR "tele dental" OR "self-instruction" or "self instruction" OR "online teaching" OR "Dental Informatics" OR "m-learning" OR "mlearning" OR "mobile learning" OR "electronic learning" OR "electronic teaching" OR "social media" OR "mobile app" OR "mobile apps" OR "software" OR "computer program" OR "website" OR "m-health" OR "mhealth" OR "mobile health" OR "telehealth" OR "tele-health" OR "tele health" OR "tele-education" OR "tele education" OR "remote learning" OR "remote teaching" OR "remote education" OR "distance education" OR "distance continuing education" OR "remote continuing education" OR "Educación a Distancia" OR "Educação a Distância" OR “educação remota” OR “educación remota” OR Teleodontología OR Teleodontologia OR "Informática Odontológica" OR “tele-educação” OR “tele-educacíon” OR “telessaúde” OR “telesalud”)))
Livivo (Sep 21, 2020)	("severe acute respiratory syndrome" OR "COVID-19" OR "COVID 19" OR "coronavirus" OR "SARS-CoV-2" OR "SARS CoV 2" OR "pandemic" OR "lockdown" OR "Coronavirus Infection" OR "Coronavirus Infections" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "2019 nCoV" OR "social isolation" OR "patient isolation" OR "Social Distance" OR "Social Distances" OR "infection control" OR "human coronavirus" OR "coronaviruses" OR "SARS virus" OR "betacoronavirus") AND ("dentistry" OR "oral medicine" OR "dental" OR "dentistry school" OR "school dentistry" OR "dental school" OR "dental schools" OR "oral medicine school" OR "Dental Specialties" OR " Dental Continuing Education" OR "Graduate Dental Education" OR "oral medicine course" OR "dental course" OR "dentistry course" OR "odontology" OR "dental curricula" OR "oral health" OR "oral health school" OR "oral health course" OR "dentistry curricula" OR "Dental Education" OR "dental undergraduate" OR "dental postgraduate" OR "dental residency" OR "dentistry undergraduate" OR "dentistry undergraduate education" OR "dental undergraduate education" OR "dentistry postgraduate" OR "dental postgraduate course" OR "dentistry residency" OR "oral health residency" OR "oral medicine residency" OR "oral health technician course" OR "dental technician course" OR "Dental Health Education" OR "dental health" OR "Dental Faculty" OR "dental students" OR "dentistry students" OR "oral medicine students" OR "oral health students" OR "dental health students" OR "dental teaching" OR "dental learning" OR "oral medicine teaching" OR "oral medicine learning" OR "dentistry learning" OR "dentistry teaching" OR "dentistry continuing education" OR "oral medicine continuing education" OR "oral health continuing education" OR "dental health continuing education") AND (“e-learning” OR "elearning" OR "computed-aided learning" OR "computed aided learning" OR "self instruction learning" OR "self-instruction learning" OR "computerized self instruction programs" OR "computerized self-instruction programs" OR "programmed learning" OR "blended learning" OR "Self-instruction Programs" OR "Self instruction Programs" OR "Self-Instruction Program" OR "Self Instruction Program" OR "Self-Instruction Programs" OR "Self Instruction Programs" OR "Programmed Learning" OR "computer assisted learning" OR "computer-assisted learning" OR "web based education" OR "web-based education" OR "computational intelligence" OR "computer vision system" OR "knowledge representation" OR "computer reasoning" OR "machine learning" OR "machine education" OR "computer based learning" OR "computer-based learning" OR "computerized programmed instruction" OR "computer assisted instruction" OR "computer-assisted instruction" OR "computerized self instruction program" OR "computerized self-

	instruction program" OR "online learning" OR "Online Education" OR "Online Educations" OR "computerized assisted instruction" OR "online courseware" OR "web based learning" OR "web-based learning" OR "education technology" OR "distance learning" OR "telemedicine" OR "tele-medicine" OR "tele medicine" OR "teledentistry" OR "tele dentistry" OR "tele-dentistry" OR "teleodontology" OR "tele odontology" OR "tele-odontology" OR "teleassistance" OR "tele assistance" OR "tele-assistance" OR "remote sensing technology" OR "teledental" OR "tele-dental" OR "tele dental" OR "self-instruction" OR "self instruction" OR "online teaching" OR "Dental Informatics" OR "m-learning" OR "mlearning" OR "mobile learning" OR "electronic learning" OR "electronic teaching" OR "social media" OR "mobile app" OR "mobile apps" OR "software" OR "computer program" OR "website" OR "m-health" OR "mhealth" OR "mobile health" OR "telehealth" OR "tele-health" OR "tele health" OR "tele-education" OR "tele education" OR "remote learning" OR "remote teaching" OR "remote education" OR "distance education" OR "distance continuing education" OR "remote continuing education")
Pubmed (Sep 21, 2020)	Search: (("severe acute respiratory syndrome" OR "COVID-19" OR "COVID 19" OR "coronavirus" OR "SARS-CoV-2" OR "SARS CoV 2" OR "pandemic" OR "lockdown" OR "Coronavirus Infection" OR "Infection, Coronavirus" OR "Infections, Coronavirus" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "2019 nCoV" OR "social isolation" OR "patient isolation" OR "Distance, Social" OR "Distances, Social" OR "infection control" OR "human coronavirus" OR "coronaviruses" OR "SARS virus" OR "betacoronavirus") AND ("dentistry" OR "oral medicine" OR "dental" OR "dentistry school" OR "school dentistry" OR "dental school" OR "schools, dental" OR "oral medicine school" OR "Specialties, Dental" OR "Education, Dental, Graduate" OR "oral medicine course" OR "dental course" OR "dentistry course" OR "odontology" OR "dental curricula" OR "oral health" OR "oral health school" OR "oral health course" OR "dentistry curricula" OR "Education, Dental" OR "dental education" OR "dental undergraduate" OR "dental postgraduate" OR "dental residency" OR "dentistry undergraduate" OR "dentistry undergraduate education" OR "dental undergraduate education" OR "dentistry postgraduate" OR "dental postgraduate course" OR "dentistry residency" OR "oral health residency" OR "oral medicine residency" OR "oral health technician course" OR "dental technician course" OR "Health Education, Dental" OR "dental health" OR "Faculty, Dental" OR "students, dental" OR "dentistry students" OR "oral medicine students" OR "oral health students" OR "dental health students" OR "dental teaching" OR "dental learning" OR "oral medicine teaching" OR "oral medicine learning" OR "dentistry learning" OR "dentistry teaching" OR "dental continuing education" OR "dentistry continuing education" OR "oral medicine continuing education" OR "oral health continuing education" OR "dental health continuing education")) AND (e-learning OR "elearning" OR "computed-aided learning" OR "computed aided learning" OR "self instruction learning" OR "self-instruction learning" OR "self instruction programs, computerized" OR "self-instruction programs, computerized" OR "programmed learning" OR "blended learning" OR "Self-instruction Programs" OR "Self instruction Programs" OR "Program, Self-Instruction" OR "Program, Self Instruction" OR "Programs, Self-Instruction" OR "Programs, Self Instruction" OR "Self Instruction Programs" OR "Self-Instruction Programs" OR "Self-Instruction Program" OR "Self Instruction Program" OR "Learning, Programmed" OR "computer assisted learning" OR "computer-assisted learning" OR "web based education" OR "web-based education" OR "computational intelligence" OR "computer vision system" OR "knowledge representation (computer)" OR "computer reasoning" OR "machine learning" OR "machine education" OR "computer based learning" OR

	"computer-based learning" OR technology OR "computerized programmed instruction" OR "instruction, computer assisted" OR "computer-assisted instruction" OR "self instruction program, computerized" OR "computerized self-instruction program" OR "online learning" OR "Learning, Online" OR "Online Education" OR "Education, Online" OR "Online Educations" OR "Learning, Distance" OR "computerized assisted instruction" OR "online courseware" OR "web based learning" OR "web-based learning" OR "education technology" OR "distance learning" OR "telemedicine" OR "tele-medicine" OR "tele medicine" OR "teledentistry" OR "tele dentistry" OR "tele-dentistry" OR "teleodontology" OR "tele odontology" OR "tele-odontology" OR "teleassistance" OR "tele assistance" OR "tele-assistance" OR "remote sensing technology" OR "teledental" OR "tele-dental" OR "tele dental" OR "self-instrucion" or "self instruction" OR "online teaching" OR "Dental Informatics" OR "m-learning" OR "mlearning" OR "mobile learning" OR "electronic learning" OR "electronic teaching" OR "social media" OR "mobile app" OR "mobile apps" OR "software" OR "computer program" OR "website" OR "m-health" OR "mhealth" OR "mobile health" OR "telehealth" OR "tele-health" OR "tele health" OR "tele-education" OR "tele education" OR "remote learning" OR "remote teaching" OR "remote education" OR "distance education" OR "distance continuing education" OR "remote continuing education") Filters: in the last 1 year
Scopus (Sep 21, 2020)	("severe acute respiratory syndrome" OR "COVID-19" OR "COVID 19" OR "coronavirus" OR "SARS-CoV-2" OR "SARS CoV 2" OR "pandemic" OR "lockdown" OR "Coronavirus Infection" OR "Coronavirus Infections" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "2019 nCoV" OR "social isolation" OR "patient isolation" OR "Social Distance" OR "Social Distances" OR "infection control" OR "human coronavirus" OR "coronaviruses" OR "SARS virus" OR "betacoronavirus") AND ("dentistry" OR "oral medicine" OR "dental" OR "dentistry school" OR "school dentistry" OR "dental school" OR "dental schools" OR "oral medicine school" OR "Dental Specialties" OR " Dental Continuing Education" OR "Graduate Dental Education" OR "oral medicine course" OR "dental course" OR "dentistry course" OR "odontology" OR "dental curricula" OR "oral health" OR "oral health school" OR "oral health course" OR "dentistry curricula" OR "Dental Education" OR "dental undergraduate" OR "dental postgraduate" OR "dental residency" OR "dentistry undergraduate" OR "dentistry undergraduate education" OR "dental undergraduate education" OR "dentistry postgraduate" OR "dental postgraduate course" OR "dentistry residency" OR "oral health residency" OR "oral medicine residency" OR "oral health technician course" OR "dental technician course" OR "Dental Health Education" OR "dental health" OR "Dental Faculty" OR "dental students" OR "dentistry students" OR "oral medicine students" OR "oral health students" OR "dental health students" OR "dental teaching" OR "dental learning" OR "oral medicine teaching" OR "oral medicine learning" OR "dentistry learning" OR "dentistry teaching" OR "dentistry continuing education" OR "oral medicine continuing education" OR "oral health continuing education" OR "dental health continuing education") AND (e-learning OR "elearning" OR "computed-aided learning" OR "computed aided learning" OR "self instruction learning" OR "self-instruction learning" OR "computerized self instruction programs" OR "computerized self-instruction programs" OR "programmed learning" OR "blended learning" OR "Self-instruction Programs" OR "Self instruction Programs" OR "Self-Instruction Program" OR "Self Instruction Program" OR "Self-Instruction Programs" OR "Self Instruction Programs" OR "Programmed Learning" OR "computer assisted learning" OR "computer-assisted learning" OR "web based education" OR "web-based education" OR "computational intelligence" OR "computer vision system" OR "knowledge representation (computer)" OR "computer reasoning" OR "machine

	learning" OR "machine education" OR "computer based learning" OR "computer-based learning" OR technology OR "computerized programmed instruction" OR "computer assisted instruction" OR "computer-assisted instruction" OR "computerized self instruction program" OR "computerized self-instruction program" OR "online learning" OR "Online Education" OR "Online Educations" OR "computerized assisted instruction" OR "online courseware" OR "web based learning" OR "web-based learning" OR "education technology" OR "distance learning" OR "telemedicine" OR "tele-medicine" OR "tele medicine" OR "teledentistry" OR "tele dentistry" OR "tele-dentistry" OR "teleodontology" OR "tele odontology" OR "tele-odontology" OR "teleassistance" OR "tele assistance" OR "tele-assistance" OR "remote sensing technology" OR "teledental" OR "tele-dental" OR "tele dental" OR "self-instruction" OR "self instruction" OR "online teaching" OR "Dental Informatics" OR "m-learning" OR "mlearning" OR "mobile learning" OR "electronic learning" OR "electronic teaching" OR "social media" OR "mobile app" OR "mobile apps" OR "software" OR "computer program" OR "website" OR "m-health" OR "mhealth" OR "mobile health" OR "telehealth" OR "tele-health" OR "tele health" OR "tele-education" OR "tele education" OR "remote learning" OR "remote teaching" OR "remote education" OR "distance education" OR "distance continuing education" OR "remote continuing education")
Web of Science (Sep 21, 2020)	("severe acute respiratory syndrome" OR "COVID-19" OR "COVID 19" OR "coronavirus" OR "SARS-CoV-2" OR "SARS CoV 2" OR "pandemic" OR "lockdown" OR "Coronavirus Infection" OR "Coronavirus Infections" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "2019 nCoV" OR "social isolation" OR "patient isolation" OR "Social Distance" OR "Social Distances" OR "infection control" OR "human coronavirus" OR "coronaviruses" OR "SARS virus" OR "betacoronavirus") AND ("dentistry" OR "oral medicine" OR "dental" OR "dentistry school" OR "school dentistry" OR "dental school" OR "dental schools" OR "oral medicine school" OR "Dental Specialties" OR " Dental Continuing Education" OR "Graduate Dental Education" OR "oral medicine course" OR "dental course" OR "dentistry course" OR "odontology" OR "dental curricula" OR "oral health" OR "oral health school" OR "oral health course" OR "dentistry curricula" OR "Dental Education" OR "dental undergraduate" OR "dental postgraduate" OR "dental residency" OR "dentistry undergraduate" OR "dentistry undergraduate education" OR "dental undergraduate education" OR "dentistry postgraduate" OR "dental postgraduate course" OR "dentistry residency" OR "oral health residency" OR "oral medicine residency" OR "oral health technician course" OR "dental technician course" OR "Dental Health Education" OR "dental health" OR "Dental Faculty" OR "dental students" OR "dentistry students" OR "oral medicine students" OR "oral health students" OR "dental health students" OR "dental teaching" OR "dental learning" OR "oral medicine teaching" OR "oral medicine learning" OR "dentistry learning" OR "dentistry teaching" OR "dentistry continuing education" OR "oral medicine continuing education" OR "oral health continuing education" OR "dental health continuing education") AND ("e-learning" OR "elearning" OR "computed-aided learning" OR "computed aided learning" OR "self instruction learning" OR "self-instruction learning" OR "computerized self instruction programs" OR "computerized self-instruction programs" OR "programmed learning" OR "blended learning" OR "Self-instruction Programs" OR "Self instruction Programs" OR "Self-Instruction Program" OR "Self Instruction Program" OR "Self-Instruction Programs" OR "Self Instruction Programs" OR "Programmed Learning" OR "computer assisted learning" OR "computer-assisted learning" OR "web based education" OR "web-based education" OR "computational intelligence" OR "computer vision system" OR "knowledge representation" OR "computer reasoning" OR "machine learning" OR "machine education" OR "computer based learning" OR "computer-based

	learning" OR "computerized programmed instruction" OR "computer assisted instruction" OR "computer-assisted instruction" OR "computerized self instruction program" OR "computerized self-instruction program" OR "online learning" OR "Online Education" OR "Online Educations" OR "computerized assisted instruction" OR "online courseware" OR "web based learning" OR "web-based learning" OR "education technology" OR "distance learning" OR "telemedicine" OR "tele-medicine" OR "tele medicine" OR "teledentistry" OR "tele dentistry" OR "tele-dentistry" OR "teleodontology" OR "tele odontology" OR "tele-odontology" OR "teleassistance" OR "tele assistance" OR "tele-assistance" OR "remote sensing technology" OR "teledental" OR "tele-dental" OR "tele dental" OR "self-instruction" OR "self instruction" OR "online teaching" OR "Dental Informatics" OR "m-learning" OR "mlearning" OR "mobile learning" OR "electronic learning" OR "electronic teaching" OR "social media" OR "mobile app" OR "mobile apps" OR "software" OR "computer program" OR "website" OR "m-health" OR "mhealth" OR "mobile health" OR "telehealth" OR "tele-health" OR "tele health" OR "tele-education" OR "tele education" OR "remote learning" OR "remote teaching" OR "remote education" OR "distance education" OR "distance continuing education" OR "remote continuing education")
Google Scholar (Sep 21, 2020)	"coronavirus" OR "covid-19" AND "dental" OR "dentistry" AND "distance education" OR "e-learning"
Open Grey (Sep 21, 2020)	("severe acute respiratory syndrome" OR "COVID-19" OR "COVID 19" OR "coronavirus" OR "SARS-CoV-2" OR "SARS CoV 2" OR "pandemic" OR "lockdown" OR "Coronavirus Infection" OR "Coronavirus Infections" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "2019 nCoV" OR "social isolation" OR "patient isolation" OR "Social Distance" OR "Social Distances" OR "infection control" OR "human coronavirus" OR "coronaviruses" OR "SARS virus" OR "betacoronavirus") AND ("dentistry" OR "oral medicine" OR "dental" OR "dentistry school" OR "school dentistry" OR "dental school" OR "dental schools" OR "oral medicine school" OR "Dental Specialties" OR " Dental Continuing Education" OR "Graduate Dental Education" OR "oral medicine course" OR "dental course" OR "dentistry course" OR "odontology" OR "dental curricula" OR "oral health" OR "oral health school" OR "oral health course" OR "dentistry curricula" OR "Dental Education" OR "dental undergraduate" OR "dental postgraduate" OR "dental residency" OR "dentistry undergraduate" OR "dentistry undergraduate education" OR "dental undergraduate education" OR "dentistry postgraduate" OR "dental postgraduate course" OR "dentistry residency" OR "oral health residency" OR "oral medicine residency" OR "oral health technician course" OR "dental technician course" OR "Dental Health Education" OR "dental health" OR "Dental Faculty" OR "dental students" OR "dentistry students" OR "oral medicine students" OR "oral health students" OR "dental health students" OR "dental teaching" OR "dental learning" OR "oral medicine teaching" OR "oral medicine learning" OR "dentistry learning" OR "dentistry teaching" OR "dentistry continuing education" OR "oral medicine continuing education" OR "oral health continuing education" OR "dental health continuing education") AND ("e-learning" OR "elearning" OR "computed-aided learning" OR "computed aided learning" OR "self instruction learning" OR "self-instruction learning" OR "computerized self instruction programs" OR "computerized self-instruction programs" OR "programmed learning" OR "blended learning" OR "Self-instruction Programs" OR "Self instruction Programs" OR "Self-Instruction Program" OR "Self Instruction Program" OR "Self-Instruction Programs" OR "Self Instruction Programs" OR "Programmed Learning" OR "computer assisted learning" OR "computer-assisted learning" OR "web based education" OR "web-based education" OR "computational intelligence" OR "computer vision system" OR "knowledge

	representation" OR "computer reasoning" OR "machine learning" OR "machine education" OR "computer based learning" OR "computer-based learning" OR "computerized programmed instruction" OR "computer assisted instruction" OR "computer-assisted instruction" OR "computerized self instruction program" OR "computerized self-instruction program" OR "online learning" OR "Online Education" OR "Online Educations" OR "computerized assisted instruction" OR "online courseware" OR "web based learning" OR "web-based learning" OR "education technology" OR "distance learning" OR "telemedicine" OR "tele-medicine" OR "tele medicine" OR "teledentistry" OR "tele dentistry" OR "tele-dentistry" OR "teleodontology" OR "tele odontology" OR "tele-odontology" OR "teleassistance" OR "tele assistance" OR "tele-assistance" OR "remote sensing technology" OR "teledental" OR "tele-dental" OR "tele dental" OR "self-instruction" OR "self instruction" OR "online teaching" OR "Dental Informatics" OR "m-learning" OR "mlearning" OR "mobile learning" OR "electronic learning" OR "electronic teaching" OR "social media" OR "mobile app" OR "mobile apps" OR "software" OR "computer program" OR "website" OR "m-health" OR "mhealth" OR "mobile health" OR "telehealth" OR "tele-health" OR "tele health" OR "tele-education" OR "tele education" OR "remote learning" OR "remote teaching" OR "remote education" OR "distance education" OR "distance continuing education" OR "remote continuing education")
ProQuest (Sep 21, 2020)	noft(("severe acute respiratory syndrome" OR "COVID-19" OR "COVID 19" OR "coronavirus" OR "SARS-CoV-2" OR "SARS CoV 2" OR "pandemic" OR "lockdown" OR "Coronavirus Infection" OR "Coronavirus Infections" OR "severe acute respiratory syndrome coronavirus 2" OR "2019-nCoV" OR "2019 nCoV" OR "social isolation" OR "patient isolation" OR "Social Distance" OR "Social Distances" OR "infection control" OR "human coronavirus" OR "coronaviruses" OR "SARS virus" OR "betacoronavirus") AND ("dentistry" OR "oral medicine" OR "dental" OR "dentistry school" OR "school dentistry" OR "dental school" OR "dental schools" OR "oral medicine school" OR "Dental Specialties" OR " Dental Continuing Education" OR "Graduate Dental Education" OR "oral medicine course" OR "dental course" OR "dentistry course" OR "odontology" OR "dental curricula" OR "oral health" OR "oral health school" OR "oral health course" OR "dentistry curricula" OR "Dental Education" OR "dental undergraduate" OR "dental postgraduate" OR "dental residency" OR "dentistry undergraduate" OR "dentistry undergraduate education" OR "dental undergraduate education" OR "dentistry postgraduate" OR "dental postgraduate course" OR "dentistry residency" OR "oral health residency" OR "oral medicine residency" OR "oral health technician course" OR "dental technician course" OR "Dental Health Education" OR "dental health" OR "Dental Faculty" OR "dental students" OR "dentistry students" OR "oral medicine students" OR "oral health students" OR "dental health students" OR "dental teaching" OR "dental learning" OR "oral medicine teaching" OR "oral medicine learning" OR "dentistry learning" OR "dentistry teaching" OR "dentistry continuing education" OR "oral medicine continuing education" OR "oral health continuing education" OR "dental health continuing education") AND (e-learning OR "elearning" OR "computed-aided learning" OR "computed aided learning" OR "self instruction learning" OR "self-instruction learning" OR "computerized self instruction programs" OR "computerized self-instruction programs" OR "programmed learning" OR "blended learning" OR "Self-instruction Programs" OR "Self instruction Programs" OR "Self-Instruction Program" OR "Self Instruction Program" OR "Self-Instruction Programs" OR "Self Instruction Programs" OR "Programmed Learning" OR "computer assisted learning" OR "computer-assisted learning" OR "web based education" OR "web-based education" OR "computational intelligence" OR "computer vision system" OR "knowledge representation (computer)" OR "computer reasoning" OR "machine

	learning" OR "machine education" OR "computer based learning" OR "computer-based learning" OR technology OR "computerized programmed instruction" OR "computer assisted instruction" OR "computer-assisted instruction" OR "computerized self instruction program" OR "computerized self-instruction program" OR "online learning" OR "Online Education" OR "Online Educations" OR "computerized assisted instruction" OR "online courseware" OR "web based learning" OR "web-based learning" OR "education technology" OR "distance learning" OR "telemedicine" OR "tele-medicine" OR "tele medicine" OR "teledentistry" OR "tele dentistry" OR "tele-dentistry" OR "teleodontology" OR "tele odontology" OR "tele-odontology" OR "teleassistance" OR "tele assistance" OR "tele-assistance" OR "remote sensing technology" OR "teledental" OR "tele-dental" OR "tele dental" OR "self-instruction" OR "self instruction" OR "online teaching" OR "Dental Informatics" OR "m-learning" OR "mlearning" OR "mobile learning" OR "electronic learning" OR "electronic teaching" OR "social media" OR "mobile app" OR "mobile apps" OR "software" OR "computer program" OR "website" OR "m-health" OR "mhealth" OR "mobile health" OR "telehealth" OR "tele-health" OR "tele health" OR "tele-education" OR "tele education" OR "remote learning" OR "remote teaching" OR "remote education" OR "distance education" OR "distance continuing education" OR "remote continuing education"))

Appendix 2. Excluded articles and reason for exclusion. (n= 15).

Author, year	Reason for exclusion
Al-Madi et al. 2020[1]	1
Al-Taweel et al. 2020[2]	2
Elledge et al. 2020[3]	3
Gautam and Gautam 2020[4]	3
Hattar et al. 2020[5]	2
Iranmanesh et al. 2020[6]	4
Iyer et al. 2020[7]	5
Laurence et al. 2020[8]	5
Lee and Chan 2020[9]	5
Peres et al. 2020[10]	5
Puljak et al. 2020[11]	3
Rahim et al. 2020[12]	2
Santos-Velázquez 2020[13]	2
Vázquez-Rodríguez et al. 2019[14]	1
Véliz and Cantarutti 2020[15]	5

1- Data collected before Covid-19 pandemic (n=2); 2- Studies in which the main objective was to describe students' perceptions and anxiety about remote education without clearly describe the adopted intervention (n=4) 3- Studies in which dental students were not the participants (n=3); 4- Studies written in non-Latin alphabets (n= 1); 5- Studies in which no online curricular teaching method was described (n=5).

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CAPÍTULO 4

THE INTRODUCTION OF ARTIFICIAL INTELLIGENCE IN DIAGNOSTIC RADIOLOGY CURRICULA: A TEXT AND OPINION SYSTEMATIC REVIEW

Short title: Artificial Intelligence in radiology curricula: a text and opinion systematic review

Type of manuscript: Systematic Review.

Authors:
Glaucia N M Santos*, DDs, Msc ORCID: 0000-0002-9955-4323
Helbert E C da Silva, DDs, Msc ORCID: 0000-0003-2662-6987
Paulo T S Figueiredo, DDs, Msc, PhD
Carla R M Mesquita, DDs, Msc, PhD
Nilce S Melo, DDs, Msc, PhD ORCID: 0000-0001-7268-485X
Cristine M Stefani, DDs, Msc, PhD ORCID: 0000-0003-4712-9779
André F Leite, DDs, Msc, PhD ORCID: 0000-0002-7803-4740

Affiliation:

Glaucia N M Santos and Helbert E C da Silva are doctoral students of the Department of Dentistry, Health Sciences Faculty, University of Brasília, Brasília, Brazil. Substantial contributions to the conception or design of the work; the acquisition, analysis and interpretation of data for the work.

Paulo T S Figueiredo, Carla R M Mesquita, Nilce S Melo, Cristine M Stefani and André F Leite are Professors of the Department of Dentistry, Health Sciences Faculty, University of Brasília, Brasília, Brazil. They drafted the work and revised it critically for important intellectual content.

The authors declare that they had full access to all of the data in this study and the authors take complete responsibility for the integrity of the data and the accuracy of the data analysis.

*Corresponding author:
Glaucia Nize Martins Santos
University Hospital of Brasília - Setor de Grandes Áreas Norte 605 - Post Code: 70840-901– Asa Norte, Brasília, DF, Brazil
Tel: + 55 61 99113-8119 nize.gal@gmail.com

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ABSTRACT

BACKGROUND: Artificial intelligence (AI) is able to emulate human performance on a task and may improve the radiologists' work. This text and opinion review explored the implementation of AI in diagnostic radiology education curricula at pre-licensure training/education in healthcare. The question was: what are the pedagogical possibilities, advantages and challenges of AI use in diagnostic radiology education?

METHODS: Primary research studies, reviews, systematic reviews, meta-analyses, letters, texts, expert opinions, expert consensus, discussion papers and guidelines about diagnostic radiology education at the undergraduate and postgraduate levels of any field of health sciences were considered. Searches were conducted on indexed databases and grey literature. Data on the context, potentials and challenges were collected from the text and opinion papers and the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Text and Opinion Papers was applied to assess methodological quality. From the experience papers, intervention, experiences and results were extracted parameters and an adapted JBI Critical Appraisal Checklist for Case Reports was applied.

RESULTS: Seventeen studies met the inclusion criteria. Personalization, training facilities and the standardization of radiology teaching were the main potentials identified. Five main challenges were also observed: the validation of AI tools in radiology education, the learning curve, universities' aptitude to teach AI, the digitization of radiological images and how to include AI in radiology curricula.

CONCLUSION: The necessity to update radiology curricula to include AI is a consensus. Time is required for development of the learning curve among AI developers, teachers and trainees. When and to what extent AI should be taught in radiology courses needs further exploration.

KEYWORDS: Radiology; Education; Curriculum; Artificial Intelligence; Machine Learning

Background

Artificial intelligence (AI), that is, the simulation of human intelligence by computational models able to emulate human performance on a task (Tecuci, 2012), is currently focused on personalized prevention and treatment strategies in healthcare (Collins & Varmus, 2015). There are two complementary approaches to defining AI: one in terms of fidelity to human performance, as a property of internal thought processes and reasoning based on psychology and the other called rationality, focused on intelligent behavior, which involves a combination of mathematics and engineering, connected to statistics, control theory and economics (Russell & Norvig, 2021).

A review of papers from the last two decades highlights an impressive process of growth, maturation and evolution of the developments in AI in education, including health education, going over and above the conventional understanding of AI as a supercomputer (Chan & Zary, 2019; Chen et al., 2020; Roll & Wylie, 2016). Currently, health education includes the use of AI in curriculum development and content personalization, teaching and pedagogical methods, assessment and communication exchanges between teachers and students (Chen et al., 2020).

The focus of radiology education is to develop trainees' skills to analyze images to find patterns, generate a differential diagnosis that matches these patterns and correlate the imaging features and differential with clinical findings to select the most probable diagnosis. The traditional apprenticeship model requires trainees to acquire and apply these skills from different sources in limited time, based on the review of preliminary reports of the staff radiologist and is dictated by the number and diversity of cases encountered, varying within practice and patient cases. As a result, knowledge and skills gained can vary a lot between trainees (Duong et al., 2019).

Considering that radiology is currently the most computer-based health specialty, AI has the potential to improve daily work. In order to support radiologists' activities, AI is mainly focused on the following subdivisions:

a) imaging processing, a mathematical process that enhances an image for the purpose of clarity, the retrieval of specific information, or pattern measurements (Mintz & Brodie, 2019);

b) machine learning (ML), the ability of a computer to learn from experience, to adapt to new circumstances and to detect and extrapolate patterns (Mintz & Brodie, 2019; Russell & Norvig, 2021);

c) deep learning, a subfield within ML which employs neural network algorithms and iterative clustering to identify connections between similar objects through constant iterations and programs using large quantities of unstructured data, complex statistical models and predicting outcomes without being explicitly programmed (Hasan Sapci & Aylin Sapci, 2020; Lameras & Arnab, 2021);

d) computer vision, the processing of an image to enable identification of the image input and to provide an appropriate output, i.e. interpretation of the image. Three main tasks are performed within medical imaging: classification, segmentation and extraction of new biomarkers from raw image data, also known as radiomics (Mintz & Brodie, 2019; Tajmir & Alkasab, 2018);

e) artificial neural network (ANN), a mathematical model based on nonlinear statistical data modelling tools where complex relationships occur between inputs and the output, creating patterns for use in decision-making processes;

f) convolutional neural network (CNN), a specific type of ANN, typically based on deep learning algorithms with several hidden layers to analyze data (Mintz & Brodie, 2019);

g) natural language processing (NLP), which consists in the ability of software tools to understand human language. NLP tools could automatically associate relevant diagnoses in each trainee's reports, compile a portfolio and automatically compare the case experience to that expected for learner's experience level (Tajmir & Alkasab, 2018);

h) Bayesian networks: provide a convenient and intuitive framework for specifying complex joint probability distributions and are thus well suited for modeling content domains of educational assessments at a diagnostic level. They are extensively used in intelligent tutoring systems, which are explicitly designed to improve students' learning, in which AI can be used as an adjunct to a virtual environment or simulation for trainees, especially relevant to surgical specialty (Chan & Zary, 2019b; Culbertson, 2016)

Therefore, AI applications in radiology include the detection of abnormalities, anatomic segmentation, image quality assessment and improvement of protocols and worklists, integrating the algorithms into the PACS (picture archiving and communication system) (Lakhani et al., 2018; Mintz & Brodie, 2019).

With the increasing number of AI studies towards radiology and the initial implementation of AI tools in routine work, this text and opinion review aims to explore and evaluate the implementation of AI in diagnostic radiology education curricula at pre-licensure training/education in health sciences. While a significant amount of literature exists regarding the use of AI in clinical radiology practice, there have been no previous experimental studies of AI possibilities and challenges in the radiologists' formation. Therefore, it is necessary to exploit the evidence derived from previous experiences and experts' opinions. This review may enlighten important implications for the planning, development and implementation of AI in diagnostic radiology education.

The objectives of this review were to summarize the current evidence and expert opinions about the pedagogical aspects of AI use in diagnostic radiology education and summarize the possibilities, advantages and challenges of this new technology in radiology undergraduate and postgraduate training. The focused question was: What are the pedagogical possibilities, advantages and challenges of AI in diagnostic radiology education?

Methods

This text and opinion review was guided by the methods of the Joanna Briggs Institute (JBI) (McArthur et al., 2020). The objectives, inclusion criteria and methods for review were documented in a protocol registered in the PROSPERO database (*University of York: Centre for Reviews and Dissemination. [Cited 2021 Oct 6]*) (http://www.crd.york.ac.uk/PROSPERO) under number CRD 42021279002. The review development and findings were reported according to the new PRISMA 2020 guidelines (Page et al., 2021).

Initial search

A preliminary search of systematic reviews from the JBI Evidence Synthesis, Cochrane Review Library, PROSPERO and PubMed for reviews identified no registered protocols nor previously published systematic reviews on the subject.

Inclusion criteria

Population (Type of participants)

This review considered texts and opinions about diagnostic radiology education at the undergraduate and postgraduate levels in any field of health sciences.

Concept

The focus of the meta-synthesis was the experiences and reflections of professors, recognized institutions and health professionals involved in diagnostic radiology education on the inclusion of AI in learners' curricula, for practical training, theoretical teaching, or contents development.

Context

The advances in AI use in diagnostic radiology are growing fast and may disrupt the way radiology is practiced. The use of AI in education involves appropriate regulation and studies prior to its introduction into curricula.

Types of evidence sources (Type of studies)

This review considered primary research studies, reviews, systematic reviews, meta-analyses, letters, texts, expert opinions, expert consensus, published discussion papers and guidelines. Books and conference abstracts were excluded.

Search strategy

The search process was conducted across Cochrane, Embase, ERIC, Lilacs, Livivo, PubMed, Scopus and Web of Science databases, as well as grey literature Open Grey, Proquest and Google Scholar (detailed information in Appendix I). The search date was from July 26, 2021, to September 12, 2021. Manual searches of the reference lists of relevant articles were also performed.

All references were managed by the reference manager software (Mendeley®, Elsevier) and duplicates were removed.

Source of evidence selection

In phase 1, two reviewers (GNMS, HECS) independently reviewed the titles and abstracts of all identified electronic database citations. Articles that did not appear to meet the inclusion criteria were discarded. In phase 2, the same reviewers applied the inclusion criteria to the full text of the articles. Both phases were completed using the Rayyan QCRI online application (https://rayyan.qcri.org). The reference lists of selected studies were critically assessed by both examiners. Any disagreement in the first or second phase were resolved by consensus between the two authors or by the decision of a third reviewer (PTSF).

Textual data extraction and presentation

Data from included papers were extracted and presented in a table using an adapted version of the standardized data extraction tool from JBI-Text and Opinion (McArthur et al., 2020). Key information included author, year of publication, country, population, context, potentials, challenges and conclusions. For experience reports, a second table with author, year of publication, country, population, intervention, experiences, results and conclusion was presented.

Methodological quality assessment of included studies

The first and second reviewers ensured a common understanding of the JBI Critical Appraisal Checklist for Text and Opinion Papers (Joanna Briggs Institute (2017) JBI Critical Appraisal Checklist for Text and Opinion, 2017) and, the JBI Critical Appraisal Checklist for Case Reports (Joanna Briggs Institute (2017) JBI Critical Appraisal Checklist for Case Series, 2017) adapted to educational experience reports (Santos et al., 2021). Both reviewers independently conducted the critical appraisal. Any disagreement was resolved by consensus or discussion with a third author.

Results

Study Inclusion

In total, 2,301 records were identified through database searching, with 1,399 remaining after duplicate removal. Additional records (515) were also identified through other sources, including grey literature and reference list checking. Titles and abstracts were reviewed according to the inclusion criteria, yielding a total of 40 studies for full-text analysis. Seventeen studies were considered suitable for inclusion in this review. Full texts considered ineligible for inclusion with reasons are listed in Appendix II. See Figure 1 for the PRISMA flow diagram on the inclusion process (Page et al., 2021).

Characteristics of the included studies

A summary of all studies included in the review is shown in Tables 1 and 2. All studies were published between 2018 and 2021. All of the included studies were primarily focused on pre-licensure training/education.

The study design included eight critical reviews (Duong et al., 2019; Fischetti et al., 2021; Forney & McBride, 2020; Gorospe-Sarasúa et al., 2021; Recht et al., 2020; Richardson et al., 2020; Simpson & Cook, 2020; Tajmir & Alkasab, 2018), four opinions (Nguyen & Shetty, 2018; Slanetz et al., 2020; Tejani, 2021; Wood et al., 2019), one letter to editor (Ellis, 2019) and four experience reports (Balthazar et al., 2020; Lindqwister et al., 2020; Wasserman et al., 2021; Wiggins et al., 2020).

Methodological Quality Assessment of Included Studies

The JBI Critical Appraisal Checklist for Text and Opinion Papers ("Joanna Briggs Institute (2017) JBI Critical Appraisal Checklist for Text and Opinion.," 2017) was elected to assess thirteen papers for methodological quality. The overall appraisal has shown that the authors' opinions had standing in the field of expertise, their central focus was the interests of the relevant population and there was reference to the extant literature. No incongruence with the literature was found, but the sources of opinions were not clearly identified in one paper (Tajmir & Alkasab, 2018). Seven papers stated positions that were not considered the result of an analytical process (Fischetti et al., 2021; Gorospe-Sarasúa et al., 2021; Nguyen & Shetty, 2018; Slanetz et al., 2020; Tajmir & Alkasab, 2018; Tejani, 2021; Wood et al., 2019).

The JBI Critical Appraisal Checklist for Case Reports ("Joanna Briggs Institute (2017) JBI Critical Appraisal Checklist for Case Series.," 2017) adapted to the educational context (Santos et al., 2021) was chosen to assess the four experience reports due to their similarity in text structure when compared to case reports. Two reports presented moderate methodological quality (Lindqwister et al., 2020; Wasserman et al., 2021) while two more showed high methodological quality (Balthazar et al., 2020; Wiggins et al., 2020). All studies clearly reported the current educational situation of the learners, clearly described the intervention and its outcomes and provided takeaway lessons. However, some reports presented methodological problems related to populations' demographic and social characteristics (Lindqwister et al., 2020; Wasserman et al., 2021), population histories not being clearly described (Balthazar et al., 2020; Lindqwister et al., 2020) and unwanted or unanticipated events not being identified (Wasserman et al., 2021; Wiggins et al., 2020).

More information about methodological assessments may be found in Tables 3 and 4.

Review findings

Experiences

Three reports were pilot studies about AI and ML inclusion to the curriculum (Balthazar et al., 2020; Lindqwister et al., 2020; Wiggins et al., 2020) and one (Wasserman et al., 2021) was a proposal. Two reports described the AI and ML teaching through webinars/lectures (Balthazar et al., 2020; Lindqwister et al., 2020). In the first study, 39% of the audience were non-radiologists, expressing interest and potential for further collaboration. Among the radiologists, 80% were residents, showing their demand for more information toward those upcoming changes (Balthazar et al., 2020). The second study demonstrated that radiology residents' interests and satisfaction in AI were high and an increased understanding of the core principles of AI was perceived after didactic sessions (Lindqwister et al., 2020).

A report proposed a curriculum change, limiting the radiology residency first year to clinical essentials, technology and data science and physics, in which ML and AI teaching were emphasized. It was expected that interns trained in this model should gain a deeper understanding of the imaging technology and familiarity with the daily challenges that technologists face (Wasserman et al., 2021).

Another report developed a Data Science Pathway for senior radiology residents, the goal of which was to provide an introduction to AI-ML through a flexible schedule of educational, experiential and research activities. The authors considered the senior year of a radiology residency to be the ideal time for immersive involvement in a curriculum covering essential skills in data science, AI and ML. Overall, the feedback was very positive, as each trainee felt able to achieve skill acquisition and research experience (Wiggins et al., 2020).

Potentials

1 – Precision radiology education

The term "precision medical education" was proposed to illustrate the use of tools and diagnostics to personalize medical education to individual learners. (Duong et al., 2019)

The first potential was identified by ten papers (Duong et al., 2019; Ellis, 2019; Fischetti et al., 2021; Forney & McBride, 2020; Gorospe-Sarasúa et al., 2021; Recht et al., 2020; Richardson et al., 2020; Simpson & Cook, 2020; Slanetz et al., 2020; Tajmir & Alkasab, 2018):

a) Adaptation to different learning styles, the identification of individual gaps in knowledge and learning needs and its possibility of providing immediate feedback and continuous monitoring (Fischetti et al., 2021; Simpson & Cook, 2020; Tajmir & Alkasab, 2018).

b) Greater acquisition of interpretative skills and correct decision making, with more objective evaluations and higher levels of detail. Decision-trees and saliency maps are examples of how AI algorithms have the potential to directly teach cognitive processes related to diagnostic decisions. Decision-trees could be applied to search possible decision points to acquire the simplest combination of points that yields the highest accuracy, while saliency map features could be identified and cross-referenced with records to recommend additional cases for review and decision-making training, supervised by an educator (Duong et al., 2019; Ellis, 2019; Forney & McBride, 2020; Gorospe-Sarasúa et al., 2021; Recht et al., 2020; Richardson et al., 2020; Simpson & Cook, 2020; Slanetz et al., 2020; Tajmir & Alkasab, 2018).

c) More effective interpretation as AI could help in the differential diagnosis of rare diseases and conditions. Bayesian networks such as the Clinical Decision Support Systems (CDS) and the Adaptative Radiology Interpretation and Education System (ARIES) are AI tools under development to improve the diagnosis and management of differential diagnoses, computing probabilities of specific diseases based on reported combinations of imaging and/or clinical features (Duong et al., 2019; Ellis, 2019; Forney & McBride, 2020; Slanetz et al., 2020; Tajmir & Alkasab, 2018).

d) Case-based education, as AI tools could identify teaching case examinations and help to automatically annotate, export and create educational modules to be introduced in the core portfolio (Duong et al., 2019; Ellis, 2019; Forney & McBride, 2020; Gorospe-Sarasúa et al., 2021; Recht et al., 2020; Slanetz et al., 2020; Tajmir & Alkasab, 2018).

2 – Radiology training facilities

This potential was addressed by nine papers (Duong et al., 2019; Ellis, 2019; Fischetti et al., 2021; Forney & McBride, 2020; Gorospe-Sarasúa et al., 2021; Recht et al., 2020; Slanetz et al., 2020; Tajmir & Alkasab, 2018; Tejani, 2021) and the following AI facilities were cited:

a) Simulations could be offered as a more consistent experience to situations (Duong et al., 2019; Ellis, 2019; Fischetti et al., 2021; Slanetz et al., 2020; Tajmir & Alkasab, 2018).

b) AI software's ability to decode human conversation could collect value information and process it from the traditional read-out procedure at radiology training (Tajmir & Alkasab, 2018).

c) Based on the examination of draft reports, an AI tool could recognize when the learner would benefit from point-of-care reference materials and automatically load them (Tajmir & Alkasab, 2018).

d) Potential reduction of the routine work and errors that are often performed by learners, which could provide more time for participating in multidisciplinary committees, interacting with other professionals, in patient care and in data analysis and investigations (Duong et al., 2019; Forney & McBride, 2020; Gorospe-Sarasúa et al., 2021; Recht et al., 2020; Tejani, 2021).

3 – Homogeneity of radiology teaching

The third potential was highlighted in seven papers (Ellis, 2019; Fischetti et al., 2021; Gorospe-Sarasúa et al., 2021; Recht et al., 2020; Slanetz et al., 2020; Tajmir & Alkasab, 2018; Wood et al., 2019). One author reported that "radiology teaching is heterogeneous in universities, as in some of them it is considered a secondary discipline" (Gorospe-Sarasúa et al., 2021), while another suggested that "models could be designed to tailor complementary curricula by aiding programs to provide more uniform training" (Slanetz et al., 2020).

4- Inclusion of AI in radiology curricula

A standardized collaborative curriculum delivered at each teaching institution was indicated by two authors (Recht et al., 2020; Wood et al., 2019). One author described the fundamentals in AI curriculum development as follows: "an ML curriculum should consist of all stages of model development, model translation and use in clinical practice (Wood et al., 2019). This includes the data collection and annotation process, algorithm selection, model development and training, model validation and assessment, requirements for clinical translation, interpretation of performance metrics and model output and identification of modes of model failure."

Based on the current literature, Figure 2 details AI potential applications in Radiology Education.

Challenges

1 – Validation of AI tools in radiology education

This topic was highlighted in four papers (Duong et al., 2019; Ellis, 2019; Gorospe-Sarasúa et al., 2021; Recht et al., 2020). One author stated that "the use of AI in education would need appropriate regulation and studies before introduction, especially given the potential impact on radiology as a specialty if AI systems provided inaccurate or substandard teaching to trainees" (Ellis, 2019). In addition, there would be a lack of comparative studies between precision radiology education and current education (Duong et al., 2019; Ellis, 2019; Gorospe-Sarasúa et al., 2021).

2 – The Learning Curve

This challenge describes the levels of AI knowledge and the requirement of at least the baseline competence by radiology learners, as highlighted by nine papers (Duong et al., 2019; Forney & McBride, 2020; Nguyen & Shetty, 2018; Recht et al., 2020; Simpson & Cook, 2020; Slanetz et al., 2020; Tajmir & Alkasab, 2018; Tejani, 2021; Wood et al., 2019).

A previous work proposed three levels of AI knowledge: AI tool creator level, AI tool deployer level and AI user level (Tajmir & Alkasab, 2018). It also confirmed that "all residents will need to attain at least baseline competence as AI users, just as they are expected to become competent in operating picture archiving and communication systems (PACS) and voice-dictation systems. They will need to judge whether tool output is plausible and meaningful before relying on it". One author stated that "radiologists will require different levels of understanding of AI depending on their roles, but it is essential for all radiologists to gain a basic understanding of AI including both its potential and limitations" (Recht et al., 2020). Two authors reported that even the baseline knowledge level would require the construction of a learning curve, in which training in AI algorithms should be included (Duong et al., 2019; Forney & McBride, 2020).

Two authors stated that learners receive little informatics information in academic education (Nguyen & Shetty, 2018; Recht et al., 2020). One of them confirmed that a "lack of advanced programming skills should not be a barrier to active engagement with AI. However, familiarity with the language of shared concepts in the field of data science would be a first step" (Nguyen & Shetty, 2018).

3 – Universities aptitude to teach AI

One author wondered if the universities were ready to teach AI (Gorospe-Sarasúa et al., 2021), while another cited that the main challenges were having greater digitization of clinical content (especially radiological images), expert systems for use in universities, better training of teachers in AI and trying to ensure that this training arrives in an equitable way to all universities (Duong et al., 2019).

It was emphasized that "delivering a standardized and robust curriculum at each teaching institution will represent a challenge, as programs may have faculty who are less well versed in this topic or lack the resources to organize formal training opportunities. Also, implementing an ML curriculum in radiology residency requires the dynamic regulatory, economic and medico-legal resolutions" (Wood et al., 2019).

4 – Digitization of radiological images

The challenge related to digitization of radiological images was cited by seven authors (Balthazar et al., 2020; Duong et al., 2019; Gorospe-Sarasúa et al., 2021; Nguyen & Shetty, 2018; Recht et al., 2020; Tejani, 2021; Wood et al., 2019). It was stated that "currently, many high-quality clinical imaging data sets to be used for training and validation are not easily accessible" (Duong et al., 2019). According to Recht et al., "diverse datasets are needed to train robust AI algorithms" and "data sharing has potential to facilitate the development of clinically relevant AI tools if barriers to data sharing are overcome and appropriate incentives are developed" (Recht et al., 2020).

5 – How to include AI in radiology curricula

Three papers highlighted time constraints, that is, deciding what to remove or shorten to make room in the curriculum for AI knowledge (Fischetti et al., 2021; Gorospe-Sarasúa et al., 2021; Simpson & Cook, 2020).

Four authors believe that end-user training for physicians could be introduced in medical school and deepened in postgraduate training and fellowship (Duong et al., 2019; Fischetti et al., 2021; Richardson et al., 2020; Slanetz et al., 2020). In turn, inside the postgraduate radiology training, three authors defended the suggestion that AI should be taught in early years (Fischetti et al., 2021; Tajmir & Alkasab, 2018; Wasserman et al., 2021) and another three in the final years of residency (Simpson & Cook, 2020; Tejani, 2021; Wiggins et al., 2020).

Discussion

This is the first systematic review to discuss texts and opinions related to the introduction of AI in undergraduate and postgraduate radiology curricula. The results indicated that AI can assist radiologists with both image interpretation and noninterpretive tasks and is able to provide more homogeneous teaching for radiology. However, the results also revealed that AI still requires adequate validation, university aptitude, the digitization of radiological images and the development of a learning curve. When and to what extent AI teaching is necessary is still unclear.

Media and some studies have shown that the emergence of AI in the field of radiology was a discouraging factor for students when choosing the specialty, due to anxiety related to radiologist replacement (Collado-Mesa et al., 2018; Gong et al., 2019; Pinto dos Santos et al., 2019; Purohit, 2019; van Hoek et al., 2019). Nonetheless, other authors stated that the majority of medical students were confident that AI will not replace radiologists (Pinto dos Santos et al., 2019; Richardson et al., 2020; Waymel et al., 2019), but reported anxiety related to a "displacement" of the radiologist's role (Gong et al., 2019). Despite these insecurities, the last decade has reported increased interest from medical students in radiology (Purohit, 2019; Slanetz et al., 2020). It therefore behooves educators to endorse AI as an opportunity, as the more informed the learners are, the less they fear this new technology (Forney & McBride, 2020; Gallix & Chong, 2019; Grayev, 2019; Purohit, 2019).

Discussions about the need for medical education reform emphasize the shortcomings of the current model of education, as AI strengths (automation, accuracy and objectivity) reached clinical and biomedical disciplines, especially imaging (Hasan Sapci & Aylin Sapci, 2020; Zanca et al., 2021). Hence, there is a great demand and untapped potential for developing educational initiatives alongside the radiology AI/ML evolution (Ooi et al., 2021). There is no consensus of when and at what level AI should be introduced throughout the educational process of an undergraduate and postgraduate learner, as it is not known how these tools will affect daily duties in the short term (Forney & McBride, 2020). All included papers agreed that an update of radiology teaching is a requirement, given that radiology is the most digitally informed of the healthcare specialties. It was suggested that AI teaching should start with the basics and radiology learners should receive at least end-user training to understand foundation concepts of the AI tools and how to interpret their outputs (Forney & McBride, 2020). However, some collected works go further, considering that to truly advance the standard of patient care, radiologists should participate in ML model development and implementation and supervise AI tools (Pianykh et al., 2020; Tajmir & Alkasab, 2018; Wood et al., 2019).

In April 2019, the European Federation of Organizations for Medical Physics established a new working group on AI in Medical Physicists, the objective of which was to structure an AI Curricular and Professional Program for physicians. The proposed curriculum consists of two levels: Basic (stratified in four subsections: a. Medical imaging analysis and AI Basics; b. Implementation of AI applications in clinical practice; c. Big data and enterprise imaging; and d. Quality, Regulatory and Ethical Issues of AI processes, all in the context of medical imaging and radiation therapy) and Advanced (a common block was proposed to be further elaborated by each subspecialty core curriculum). The learning outcomes of the training were presented as knowledge, skills and competences (Zanca et al., 2021). In the United States, senior residents are sponsored to attend a one-week online National Imaging Informatics Curriculum and Course, which includes basic data sciences and ML concepts as its objectives (*National Imaging Informatics Curriculum and Course | RSNA*, 2016). As reported, AI implementations in medicine education are still taking shape because even the basic AI curricular architectures are still in relatively early development.

Radiographers have had difficulties acquiring AI-related continued education, mainly because there is a lack of educational courses to assist post-qualification training. The causes of this include faculty resistance, the complexity of use, quality of supporting evidence and costs (Pitts et al., 2013). The statistics corroborate the Rogers' Diffusion of Innovations theory, which showed that only 15% of innovators and early adopters are self-motivated to understand more about AI/ML, while the majority will require a formalized curriculum to obtain knowledge (Ooi et al., 2021; Rogers, 2010). The overflow of information and the fast evolution in this field could paradoxically be discouraging radiologists from individual learning, especially those who think that a strong technical background is required (Waymel et al., 2019). However, a French survey reported that nearly all respondents would attend a dedicated training on AI if available and the majority would even consider attending a technically advanced one, such as programming or neural network training courses (Waymel et al., 2019).

The authors agreed that adding value to patient care was a goal, so trainees should be able to judge when tools were applicable to clinical situations and could evaluate whether a given tool worked as expected in their practice (Forney & McBride, 2020; Gorospe-Sarasúa et al., 2021; Obermeyer & Emanuel, 2016; Richardson et al., 2020; Tajmir & Alkasab, 2018; Wood et al., 2019). In addition, the use of AI in healthcare that involves personal health information also requires guidelines about data protection and privacy to structure these relationships in an ethical manner (Forney & McBride, 2020; Gorospe-Sarasúa et al., 2021; Recht et al., 2020; Tejani, 2021).

Radiology students and trainees are susceptible to automation bias, which refers to the notion that the computer is more reliable than humans because it is a machine (Challen et al., 2019; Obermeyer & Emanuel, 2016; Raymond Geis et al., 2019; Reyes et al., 2020). Also, some papers highlighted the tendency to reduce the amount of normal cases from the worklist. This action might increase the probability of abnormal or complex examinations and lead to premature fatigue (Richardson et al., 2020; Simpson & Cook, 2020; Slanetz et al., 2020; Tajmir & Alkasab, 2018). Therefore, the radiology profession will inevitably become more dependent on automated tools. Deciding which skills should be allowed to atrophy and the subsequent impact on clinical performance requires more research (Richardson et al., 2020).

Democratization in AI is a key concern and inequalities in the use of AI in resource rich and poor environments seem inevitable. AI could be used to improve radiologists' and learners' decision-making in rich countries, where a new generation of radiologists would be suited to the era of AI, while it could replace human expertise in poor regions, where radiologists would have little access to proper training (Kobayashi et al., 2019; Schönberger, 2019).

Limitations of the review

Overall, it is important to highlight the challenges related to teacher training in AI, as the literature is not yet focused on this topic. Although any level of radiology courses in health sciences was considered for inclusion in this review, only medical learners were addressed. Moreover, all of the included studies are from developed countries, which implies that AI teaching is not a real concern in middle-/low-income countries to date. Learners' perception and anxiety and ethical issues were not fully assessed in this systematic review, even though they are of great importance when proposing a new educational curriculum.

Conclusions

This review showed a consensus opinion regarding the necessity to update radiology curricula with AI topics. From all of the included texts and opinions analyzed, advantages to AI implementation were found. General applications include case-based simulations, the personalization and standardization of education and immediate feedback. Specifically, shifting the subjective image interpretation to a quantitative and automated way through radiomics and improving the reports' writing and cataloguing could decrease errors and develop a rich archive for studies and cases comparisons. However, to exploit these possibilities, the validation of AI tools, universities' aptitude to teach AI and the digitization of radiological images are obstacles to overcome. Moreover, time is required for development of the learning curve among AI developers, teachers and trainees. When and to what extent AI should be taught in undergraduate and graduate radiology courses needs further exploration.

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Glaucia N M Santos and Helbert E C da Silva contributed substantially to the conception or design of the work and the acquisition, analysis and interpretation of data for the work. Paulo T S Figueiredo, Carla R M Mesquita, Nilce S Melo, Cristine M Stefani and André F Leite drafted the work and revised it critically for important intellectual content.

Fig 1 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources

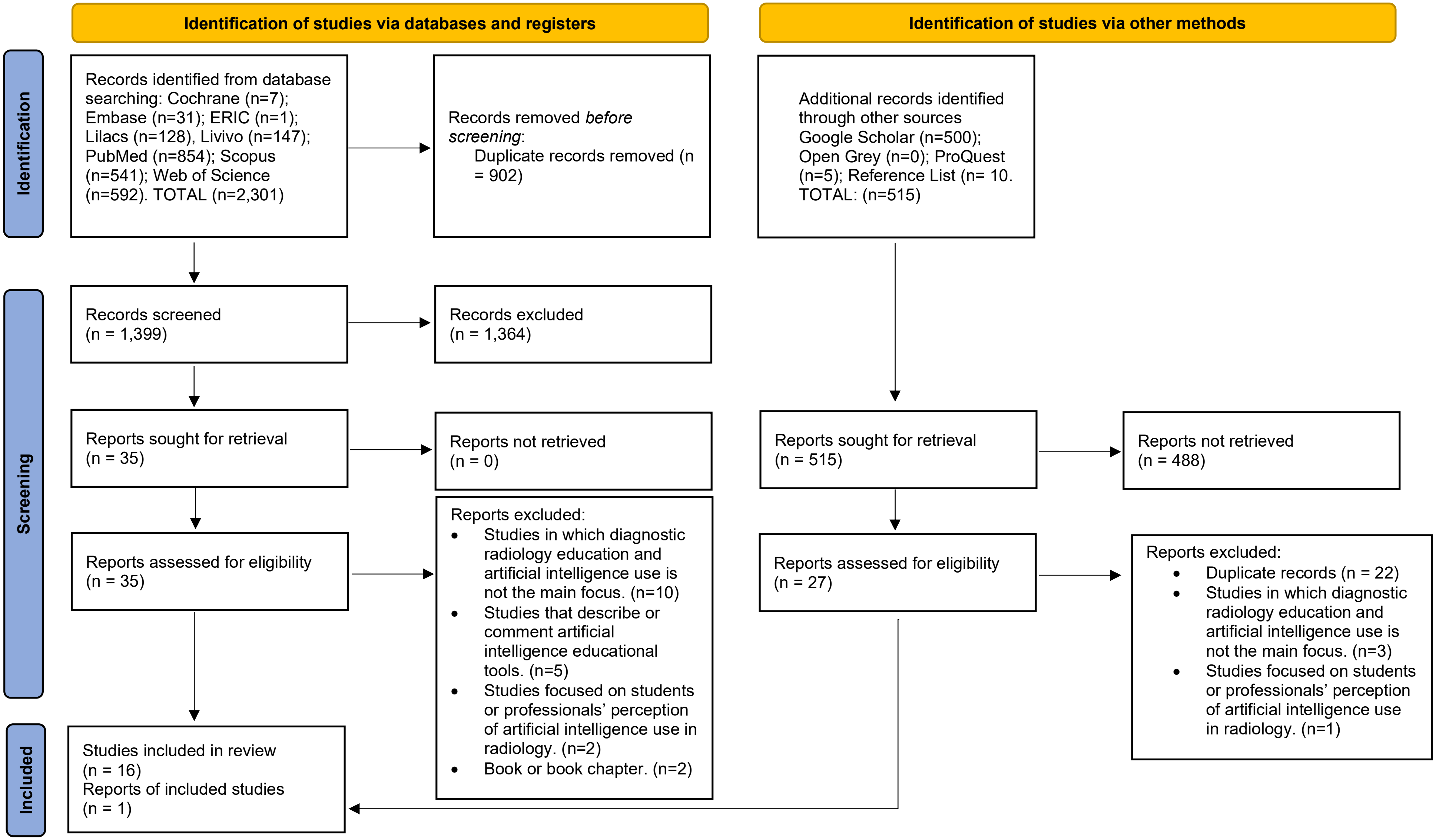
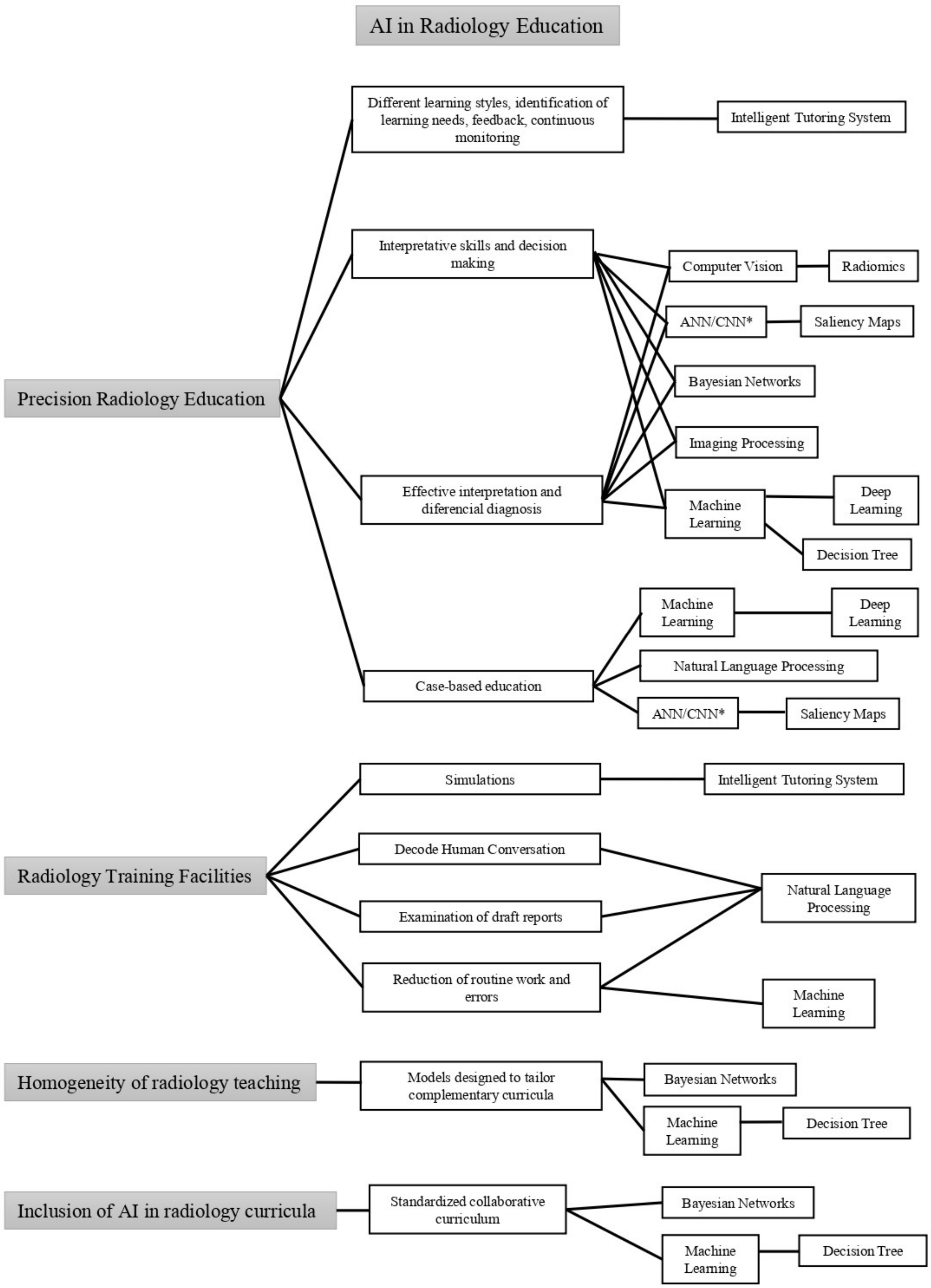


Fig 2 Flow diagram of AI potential applications in Radiology Education based on the current literature.



*ANN/CNN: Artificial Neural Networks/Convolutional Neural Networks

Table 1. Summary of descriptive characteristics of included papers (n=13).

Author/ Country	Population	Context	Potentials	Challenges	Conclusions
Duong et al., 2019 (USA)	Medical radiology residency	Concept of "precision medicine education", in which learning environments are adapted to individual learners on case-by-case basis, leveraging previous research on applying AI to match students' learning styles and provide feedback.	Addition of AI to post-graduate education may directly assist trainees in augmenting caseloads with necessary breadth and depth of cases. AI offers ideal opportunities to present case-based learning. Guided decisions can strengthen proper reasoning and provide examples of correct decision-making. Supervisors and trainees may spend less time reviewing basic ideas and more time on deeper discussions of radiologic and clinical principles. AI techniques promote interactive flipped learning for personalized education. High fidelity-simulations allow practicing for clinical encounters.	AI techniques require significant, rate-limiting research, development and real-world validation. For successful implementation, there will be a significant learning curve, for physicians, technologists and engineers. Currently, many high-quality clinical imaging data sets to be used for training and validation are not easily accessible. There have been few if any head-to-head comparisons between traditional learning and AI-augmented medical or radiology education.	The major incentive for AI-augmented radiology precision education is the opportunity to potentially improve performance through individualized learning. A reference frame from behaviorist, cognitive, and constructivist aspects of radiology education presents current challenges and potential solutions of how to tailor allocation of resources to individual trainees, adapting to personal learning needs. End-user training for physicians can be introduced in medical school and deepened in post-graduate training.
Ellis, 2019 (United Kingdom)	Foundation doctor in a district general hospital.	Response to Duong et al., (2019) paper.	AI precision education could regulate the amount of formal radiology teaching received by United Kingdom students, providing students a more consistent exposure and experience to situations. Addressing and correcting cognitive bias give students more opportunity to correct and explain mistakes. AI may be useful in adapting to different learning styles and giving feedback in a class setting. AI	The use of AI in education would need appropriate regulation and studies before introduction, especially given the potential impact on radiology as a specialty if AI systems provided inaccurate or substandard teaching to trainees.	It would be paramount for future research to explore AI and precision education in radiology compared to current educational methods. If positive results were found it would be interesting for future studies to assess the effect of precision education on junior doctors in smaller hospitals compared to larger ones, and also on medical students with different course structures.

			integrated to portfolio could identify individual gaps in knowledge and learning needs. Rarer diagnoses may be more difficult to correctly identify and an AI framework could benefit smaller hospitals where junior doctors are less likely to see rarer cases by flagging up differentials they may not have considered, taking into account the clinical information provided. As there is a lack of specific radiology training and curricula in foundation doctor, AI could have a useful role in developing junior doctors' radiology knowledge if "must-see" cases and assessment were introduced as part of the core portfolio.		
Fischetti et al., 2021 (USA)	Medical school and medical non-radiology residencies	Overview of radiology education within current medical education curricula, and also how AI may potentially impact the current radiology education model.	AI models, which use the approach of pattern recognition and repetition, can be integrated into real-time technology. Because of the immediate feedback, AI has come to play a role in the hands-on learning and teaching that occurs with more portable radiologic equipment. These opportunities for quick and personalized feedback will continue to help expand educational opportunities for the learner and are some ways in which medical school curricula can capitalize on this newly available technology.	There is no consensus on how or when radiology education should first be introduced at the medical trainee or non-radiology resident education level. The modalities and formats in which radiology is taught are varied. Such variations among institutions have at times, resulted in a deprioritizing the goal of understanding radiology as a medical student.	As the field of radiology is most prominently affected by AI, it also presents a natural starting point for integration of AI into medical education. This especially holds true given radiology's inconsistent role and methodology of instruction in present medical education curricula. If integrated correctly, the preclinical radiology curriculum can focus on learning how to read diagnostic images, interpreting statistical models of AI, and even optimizing ways to develop them if students are interested. Not only does AI potentially impact the opportunity to triage and sort through the surplus of medical

					imaging, but it can also provide a way to better improve learning among trainees.
Forney & McBride, 2020 (USA)	Medical radiology residency	One of the cutting-edge technologies that is rapidly growing in importance is AI, which offers a new toolbox to radiologists. Exactly how much radiology trainees need to learn about AI is not an easy question to answer, especially because it is not yet clear how AI tools will affect the daily duties of a radiologist. Trainees must comprehend the basic concepts behind the AI processes and the scope of the reference data from which they achieve their ability to function.	AI can be involved in every step of the imaging department including ordering and scheduling, protocoling and acquisition, workflow and image interpretation. Many of these applications have the potential to reduce the routine work that is often performed by residents and provide more time for learning radiology. Gaining objectivity in the evaluation of evaluators is helpful, and AI algorithms may be able to automate this process. In addition, residents seek timely feedback. AI applications offer relief from the increasing administrative burden. They also have the ability to provide more objective evaluations with higher levels of detail. Because much of our evaluation of medical trainees falls on the subjective end of the spectrum, trends are difficult to identify and manage. AI applications may identify these trends and patterns and may help to train the radiologists of the future more effectively.	Residents should ethically assess the data set on which AI algorithms are built, and understand that data can vary in multiple parameters. They must consider how their patient populations, practice preferences, and image acquisition parameters affect their ability to apply a new AI algorithm to their practices. Residents should also be trained to consider where and when to implement new AI algorithms.	Residents who see the range of AI applications in radiology are less likely to view the technology as a threat. Radiology training programs should identify individuals with knowledge of tool creation or tool deployment to help train radiology residents. As a group, radiologists and trainees should continually consider the effect of AI tools on their final interpretations, and on a broader level, they should consider whether these tools truly add value to patient care.
Gorospe-Sarasúa et al., 2020 (Spain)	Medical school and medical radiology residency.	This paper discusses some challenges to incorporate AI at different levels of education, from undergraduate to continuous education, in order to break the negative expectations AI	Thanks to the liberation of the most tedious and repetitive tasks of the work, radiologists of the future will have a central role in the integrated management of data (not only radiological, but also demographic, clinical, and laboratorial, etc). Delegating more routine tasks to AI tools, humans may focus on tasks with greater value.	An alternative position would be to link basic AI teaching to radiology training, as a further technological development. However, some universities are not read to teach AI. In addition, the teaching of radiology in universities is heterogeneous. There are also time constraints on embedding AI into the curriculum.	Scientific evidence is necessary to show that AI-based training is better than traditional teaching and the ethical considerations should be included. It is desirable that only when a resident has internalized a sufficient number of studies, they can have access to AI tools and learn how

		has imposed on the choice of radiology as a specialty.	There will be more time for teaching and research. AI will help radiologists not interpret images in a decontextualized way without glimpsing their clinical impact, and will allow professionals to integrate this information with many other data, thus achieving greater prominence and greater visibility among patients.		their algorithms work, in what scenarios they can be used and when they do not work in an expected way.
Nguyen & Shetty, 2018 (USA)	Medical radiology residency	With a long time, horizon for AI to impact the careers and practice landscape of current trainees, much is at stake, and avoiding AI is simply not a viable option. For better or worse, the fact remains that the individuals and groups paving the way and securing millions of dollars in funding in transforming how radiology is practiced are not practicing radiologists.	Looking toward the future, it is expected radiologists to recognize and understand reasons underlying an error of a deep learning malignancy classification model. The better radiologists can understand and communicate the same language with back-end developers, the smoother the integration will be.	Lack of advanced programming skills should not be a barrier to active engagement with AI. However, familiarity with the language of shared concepts in the field of data science would be a first step. That is still the early phases of AI's integration with radiology with much work to be done. A large gap in understanding still separates the data scientists and AI engineers from the clinical radiologists with respect to each of our capabilities and limitations.	Firstly, identifying faculty members and leaders who have a bent toward clinical informatics and AI. Alternatively, opportunities for collaboration exist with industry and start-up leaders in AI.
Recht et al., 2020 (USA/ Germany/ Netherlands/ Austria/ United Kingdom)	Medical radiology residency	Stakeholders are working to develop AI solutions for radiology. Each stakeholder has strengths and weaknesses in terms of their access to the knowledge, expertise, data, and other resources necessary for success. Partnerships	The adoption of AI will expand the necessary knowledge base of radiologists. It will be the radiologists' responsibility to interpret and contextualize the output of algorithms into information and knowledge that will positively impact patients' outcomes. AI also offers new opportunities for knowledge gain. AI tools may be able to customize an educational plan for each individual trainee/radiologist.	The creation of the educational resources necessary to train all roles within radiology will require the cooperation of national and international societies as well as academic departments. A standard curriculum will need to be developed for radiology trainees. It is clear that individual programs will not have the	The least amount of knowledge that will be required is for the AI tool users. This group will need to understand some basic AI concepts and be able to recognize when algorithms are not performing as intended, similar to how practicing radiologists need to understand when imaging artifacts are present, even if they cannot explain why the

		between academic healthcare organizations and industry will be important in achieving progress in imaging AI. These issues and possible solutions were discussed at the 2019 meeting of the International Society for Strategic Studies in Radiology held in Budapest.	By replacing human labor in repetitive and time-consuming tasks, AI may increase the purpose and sense of satisfaction of radiologists themselves as well.	competencies required to establish a program on their own for many years. Issues that need to be addressed include the ethical development and use of AI in healthcare, the appropriate validation of each developed AI algorithm, the development of effective data sharing mechanisms, regulatory hurdles for the clearance of AI algorithms, and the development of AI educational resources for both practicing radiologists and radiology trainees.	artifacts occur or how to eliminate them. Fortunately, there are already precedents in radiology education for collaboratively creating such a curriculum. AI innovation in radiology is likely to be driven by academic healthcare organizations in partnership with industry. Guidelines are needed to structure these relationships in an ethical manner.
Richardson et al., 2020 (USA)	Radiology education and residency training	AI can be used to solve a wide range of noninterpretive problems that are relevant to radiologists and their patients, including academic radiology.	Improving the quality and efficiency of radiology education by identifying knowledge gaps and areas in which the resident needs greater clinical exposure. Automated correlation of radiology findings with pathology results, operative reports, and clinical outcomes using AI tools would be an area in which the educational experience could be improved. Educators may be able to create teaching materials that adapt to student's abilities in real-time. AI tools might also help in tracking radiology resident performance and evaluate competency.	Radiologists may become more dependent on automated tools. Deciding which skills should be allowed to atrophy and the subsequent impact on clinical performance will be important questions moving forward. If radiology residents are directed to only examine cases with positive findings, those residents will lose experience in identifying negative cases, which are important for learning the spectrum of normal variation.	The ultimate goal of AI in medical imaging is to improve patient outcomes. This approach could be strengthened by dedicated rotations in information technology during residency training, and fellowships.
Simpson & Cook, 2020 (USA)	Medical radiology residency	Framing the discussion of how AI will affect the trainee experience in the context of how radiology residents and fellows are taught today may serve to reassure future radiology residents that they will	AI can be a useful adjunct in helping residents to track their progress through training, by automatically identifying activities that are completed or milestones that are achieved. By analyzing radiology resident performance using AI, there is greater potential to provide personalized resident feedback.	It is important to consider how, when, and to what extent we should teach radiology residents about AI itself. The challenge in adding more required components to the residency arises when deciding what to remove or shorten to make room in the curriculum for new knowledge.	AI requires changes to radiology trainee education. Current and future residents and fellows will need to know how to interpret AI outputs, in addition to knowing how to interpret images. They will need to understand how AI modifies the clinical workflow and be sensitive to AI outputs that seem unusual or

		have a meaningful career augmented by AI. As newer educational methods permeate radiology, incorporation of AI into education delivery can offer new methods for residents to learn clinical radiology.	AI built into the dictation system could be used to identify areas of uncertainty that residents encounter while interpreting examinations during daytime rotations. The potential role of AI in evaluating radiology trainees' preparedness for independent call and independent practice should also be considered.	Although there are obvious benefits in removing normal cases from the worklist, the impact of this on training should not be ignored.	incongruent. Although what role AI will play in the practice of radiology remains undefined, it will surely be integrated into the education of future radiologists. An option would be to first teach junior residents the traditional methods of image interpretation before exposing them to AI; however, the practicality of this approach would have to be balanced against the pervasiveness of AI in clinical practice.
Slanetz et al., 2020 (USA)	Medical radiology residency and fellowship	The role of AI and ML in medical education is not clear. AI will affect radiology training in three main ways: learning the fundamentals of radiology AI, working with AI in the interpretive context, and using AI to enhance teaching and learning of radiology during residency and fellowship.	ML allows for outcome prediction and decision personalization, which can potentially optimize radiology education. It promises to improve workflow, enhances reporting, and aids in providing better image interpretation and personalized management decisions for patients. Models could be designed to tailor complementary curricula by aiding programs to provide more uniform training. At the individual resident level, ML algorithms could assess resident performance and then reiterate key concepts being missed or misinterpreted. Learning basic concepts of ML allow learners to evaluate the quality of the outputs being provided and troubleshoot erroneous outputs. AI and ML allow the development of standardized case sets and tailor education for individual trainees to achieve high levels of competence, without subjectivity.	AI use may reduce the number of normal cases seen by the radiologist; cases that are viewed can induce a bias that they are all abnormal. Thus, as educators, it is critical to incorporate normal cases into the standard residency curriculum. AI has potential for decreasing the number of studies interpreted, increasing the probability of abnormal or complex ones and leading to premature fatigue.	It is quite likely that ML will eventually be considered a modality of radiology. It is also likely that residents will eventually be able to pursue a fellowship in ML, which will be essential to ensure high-quality imaging, accurate image interpretation, and optimal service to patients and referring providers. Feedback confirms that most residents are strongly interested in receiving formal didactic sessions on AI concepts.

Tajmir & Alkasab, 2018 (USA)	Medical radiology residency and fellowship	Computer vision AI systems will likely perform classification, segmentation, and extraction of new biomarkers from raw image data. NLP is the ability of software tools to understand human language. The purpose of this study was to suggest paradigms for how radiologists should approach these new tools as they are developed and deployed across the clinical enterprise, paying special attention to the potential short-term and long-term effects of AI/ML on radiology education.	ML-trained AI tools will likely focus on helping radiologists recognize image features and characterize them. An AI tool could identify examinations which should become teaching cases and help automatically annotate, export, and create educational modules from them. Where particular pathologies are under-represented, the system could generate teaching file cases for use in a work list for individualized education. Continuous monitoring can avoid the problem of trainees being reluctant to ask for help by automating the process of bringing in supervision. The monitoring tool could automatically document the conversation the trainee has with the patient care teams for the attending to review. Artificially intelligent NLP can help trainees to create better reports and avoid common pitfalls. ML-trained NLP could recognize the clinical meaning of reports and make comparisons among different versions of the text. Finally, given the AI-driven improvements in software's ability to "understand" normal human conversation, much more value could be extracted from the traditional read-out process at the heart of radiology training. Based on examination of the draft reports, an AI tool could recognize when the radiologist would benefit from point-of-care reference materials and automatically load the relevant table or figure.	There are three levels of knowledge that radiologists will need: AI tool creators, AI tool deployers and AI-using radiologists. Residents will need to attain at least baseline competence as AI users. They will need to judge whether tool output is plausible and meaningful before relying on it. Radiologists are taking on a new responsibility on top of image acquisition and interpretation: active supervision of AI tools. Training programs need to ensure actual residents and fellows are not cut out of the interpretive loop on both normal and abnormal examinations simply because an AI system has already predicted the case.	Radiology training programs will need to develop curricula to help trainees acquire the knowledge to carry out this new supervisory duty of radiologists. This new curriculum will need to foster an understanding of how ML-based algorithms work so that trainees are able to judge when tools are applicable to clinical situations and evaluate whether a given tool is working as expected in their practice. Training programs could begin by compiling training resources on what is ML, how it is different from prior automated approaches, and what errors it is prone to.

Tejani, 2020 (USA)	Medical radiology residency	AI and ML continue to dominate conversations from large academic conferences to one-on-one trainee interviews. However, a formal curriculum has not been established to teach residents how to assess the potential uses and limitations of AI applications. Furthermore, there remains a need to educate residents on the regulatory, ethical, and economic implications of adopting AI. We must examine barriers impeding the deployment of a framework to prepare radiologists for active participation in the creation and execution of ML algorithms.	PGY 5 "mini-fellowships" dedicated to AI may appeal to educators with concern for compromised clinical training secondary to dedicated AI education during PGYs 2 to 4 years. This option allows a rotating, standardized curriculum offered every few months in PGY 5 featuring lectures from computer science, informatics, and clinical faculty members with set time for project completion. Furthermore, offering "tracks" in AI and informatics, in tandem with clinical rotations, provides an option for resident-directed time commitment to AI education.	The implementation of a successful AI curriculum demands accommodation for differing levels of trainee background in ML and desired level of interaction with AI tools. Not every program provides time and financial support to encourage participation. An ideal solution consists of program encouragement for supplementary education through monetary support or local content provision. Constant creation of new algorithms and updates in the ethical, legal, and economic context of AI implementation necessitate a solution to reflect these changes in an AI curriculum. A possible solution for this barrier features the creation of local workgroups tasked with periodically updating institution faculty and curricular content. A national task force of experts could centralize responsibility and address disparity in the levels of AI expertise across institutions, disseminating periodic updates to program representatives.	Support from faculty champions for dedicated AI education outside of required resident rotations is crucial for curricular implementation. An ideal solution consists of program encouragement for supplementary education through monetary support or local content provision. It is necessary to administer local, program-specific examinations to determine trainee mastery and evaluate program effectiveness. Trainee performance may be used as an objective marker of program success to justify continued investment in providing AI education.
Wood et al., 2019 (USA)	Medical radiology residency	If radiologists are expected to utilize ML models safely and effectively for imaging interpretation, education for all levels of background and experience will be required, and a formalized ML curriculum targeted	A ML curriculum should consist of all stages of model development, model translation, and use in clinical practice. This includes the data collection and annotation process, algorithm selection, model development and training, model validation and assessment, requirements for clinical translation, interpretation of performance metrics and model output,	The need for a structured curriculum is exacerbated by the unintuitive ways in which ML models can fail. Delivering a standardized and robust curriculum at each teaching institution will represent a challenge, as programs may have faculty who are less well versed in this topic or lack the resources to organize formal training opportunities. Also, implementing an ML curriculum in radiology residency	To truly advance the standard of patient care, radiologists will not only be required to appropriately consume ML model output but also to participate in its development and implementation to ensure that the most critical challenges in the profession are addressed. There are many recognized organizations that are well positioned to formulate a consensus curriculum among the

		toward early career radiologists and trainees is urgently needed.	and identification of modes of model failure.	requires the dynamic regulatory, economic, and medico-legal resolutions. Given the potentially limited number of local faculty mentors, a national network of mentors could be established to allow exposure to these opportunities to trainees across the country.	nation's leading radiologists and imaging scientists to provide didactic material to meet the needs of the field. Such a proposed curriculum should be vetted by the ABR, the Association of Program Directors in Radiology, the ACGME's Residency Review Committee, and other relevant groups.

AI = Artificial Intelligence; ML = Machine Learning; NLP = Natural Language Processing; PGY = postgraduate year; ABR = American Board of Radiology; ACGME = Accreditation Council for Graduate Medical Education

A summary of all studies included in the review is shown in Tables 1 and 2.

Table 2. Summary of descriptive characteristics of experience reports included studies (n=4).

Author/ Country	Population	Intervention	Experiences	Results	Conclusion
Balthazar et al., 2019 (USA)	Medical residency	The American College of Radiology Resident and Fellow Section created an AI Advisory Group to oversee the creation of the AI journal club, a six-person group that meets virtually to curate topics and potential panelists to give interactive webinars.	First, interactive webinars discussing the role of radiologists as knowledge experts in a world of AI. Subsequent journal clubs have discussed wide-ranging topics including both radiology and non-radiology topics so that participants can have greater exposure to what AI can do well and what still is a new frontier. The panelists have been comprised of leaders in radiology and computer scientists to share their respective viewpoint and bridge their expertise. Each journal club occurs monthly for 1 hour where invited panelists discuss a topic for approximately 30 minutes and then a moderator asks questions posed by the audience members to facilitate discussion.	The results show that 39% of the audience were non-radiologists which perhaps expressed the interest and the potential for further collaboration. Among the radiologists, 80% were residents, which perhaps expressed the demand for more information/ knowledge toward those upcoming changes. The second session "How to read and critique deep learning papers" was the most popular journal club. AI/ML applications are subject to errors and failures. Therefore, it is essential to never become complacent or blindly accept these algorithm predictions. The major limitation of the AI Journal Club is that it does not represent a comprehensive AI curriculum and therefore does not address the current lack of a standardized resource to cover the foundation of AI/ML for radiologists.	A national AI curriculum for practicing radiologists and radiology trainees is needed, as well as more interdisciplinary collaboration for a better learning experience. While the AI Journal Club does not represent a comprehensive and in-depth AI curriculum, its creation was an important first step in formal AI training for radiologists
Lindqwister et al., 2020 (USA)	Medical radiology residency	It is presented a model for a successful introductory curriculum into AI in radiology titled AI-RADS. This pilot course was created with the goal of	Lectures were held once per month for a total of 7 months. Each lecture consisted of an algorithm in AI along with supporting fundamental concepts in computer science. Didactic sessions were reinforced with active discussion by a concurrent journal club highlighting the algorithm discussed in the previous lecture. Each 2-hour journal club	The content depth of the AI-RADS lecture series was considered ideal. Surveys demonstrated a high degree of learner satisfaction (9.8/10). Resident interest in AI has remained high, suggesting that this course has not deterred learners from the field. An increased understanding of core	AI will become an essential skill for interpreting medical literature, assessing potential clinical software augmentations, formulating research

		imparting an intuitive understanding of the strengths and limitations of ML techniques along with an intellectual framework to critically evaluate scientific literature on the subject.	was held 2 weeks after its corresponding lecture. Describe foundational algorithms in AI, their intellectual underpinning, and their applications to clinical radiology; Proficiently read journal articles on AI in radiology; Identify potential weaknesses in AI algorithmic design, database features, and performance reports; Identify areas where AI techniques can be used to address problems. Describe different ways information can be abstractly represented and exploited; Demonstrate a fluency in common "buzzwords" in AI.	principles of AI was perceived after didactic session. Journal club was initially successful, but demonstrated a progressive decline in learner preparation, which was evident in later discussions. Limitations of the course include heterogeneity of learner attendance, usually as a result of the clinical duties of certain rotations, scheduling, and resident burnout.	questions, and purchasing equipment. By having an intuitive foundation of ML, learners will be better equipped to understand its strengths and weaknesses and be empowered to make more informed decisions. Proficiency in AI will be a required skill in the near future of imaging services.
Wasserman et al., 2021 (USA)	Medical radiology residency	A technocentric pedagogy at the initiation of training is proposed based on the incorporation of a comprehensive technology and physics-based educational curriculum in lieu of the current 12-month clinical internship. This new preliminary year is named the "TechnoPhysicsYear", based on the following elements: clinical essentials, technology (emphasizing ML) with data science, and physics.	The use of "modality-immersion" is a suggested learning technique that melds the physics regimen with technology and innovation. It is believed that embedding diagnostic radiology interns in modality-based rotations, in order to learn the basics of scanning actual patients, would benefit those interns more than multiple clinical rotations that provide little with regard to radiology education. Such "practical" rotations would involve instruction by, observation of, and interaction with technologists in multiple modalities. Non-clinical skills such as medical economics and physician payment policy systems could also be introduced as part of the curriculum.	Interns trained with TechnoPhysics model may gain a deeper understanding of imaging technology, an appreciation for the patient experience, and familiarity with the daily challenges that technologists face. It could also be argued that learning more about the duties and responsibilities of radiology technologists would be essential before assuming the role of a physician leader in this field. A pilot study of the TechnoPhysics program, after the development of a specific curriculum, is in order.	It is time for educational leadership to acknowledge this issue lest they risk appearing tone-deaf to the next generation of radiologists. It is proposed a project that leads to the granting of special certification in imaging technology and medical physics, bestowed upon graduation, at the end of the diagnostic R4 year.
Wiggins et al., 2020 (USA)	Medical radiology residency	To address the growing interest among residents and	The senior year of a radiology residency is an ideal time for immersive involvement in a	Overall, the feedback from the first cohort was very positive. Each trainee felt they were able to achieve their	This experience showed that an integrated DSP is

		the need for radiology-trained leaders in data science, it was developed a DSP for senior radiology residents, which goal was to provide an introduction to AI-ML through a flexible schedule of educational, experiential and research activities. Here it is described the experience with the first trainee cohort and the establishment of a formal AI-ML curriculum for future residents based on pilot feedback.	curriculum covering essential skills in data science, AI and ML. Trainees proposed 3, 6, and 8-month DSP plans based on individual learning goals. A mixture of consecutive and sporadic DSP blocks was allocated for each resident, accounting for clinical rotations, vacation, and parental leave time. Residents provided detailed reports documenting their accomplishments and progress toward predefined learning objectives at the end of a 6-week trial period.	goals for skill acquisition and research experience. The next generation of radiologists needs clinical leaders in AI and ML to help drive the field toward clinical utility and to improve patient outcomes.	feasible for trainees with varying technical backgrounds. Lessons learned from the first iteration of the DSP will improve the experience for subsequent trainees. This curriculum and the description of this experience may serve as a model for comparable programs at other institutions.

AI=Artificial Intelligence; ML=Machine Learning; DSP = Data Science Pathway

A summary of all studies included in the review is shown in Tables 1 and 2.

Table 3 – Final Methodological Quality Assessment Table (from the JBI Critical Appraisal Checklist for Text and Opinion Papers)

Papers / **Checklist Questions**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Duong et al., 2019	Yes	Yes	Yes	Yes	Yes	No
Ellis, 2019	Yes	Yes	Yes	Yes	Yes	No
Fischetti et al., 2021	Yes	Yes	Yes	No	Yes	No
Forney & McBride, 2020	Yes	Yes	Yes	Yes	Yes	No
Gorospe-Sarasúa et al., 2020	Yes	Yes	Yes	No	Yes	No
Nguyen & Shetty, 2018	Yes	Yes	Yes	No	Yes	No
Recht et al., 2020	Yes	Yes	Yes	Yes	Yes	No
Richardson et al., 2021	Yes	Yes	Yes	Yes	Yes	No
Simpson & Cook, 2020	Yes	Yes	Yes	Yes	Yes	No
Slanetz et al., 2020	Yes	Yes	Yes	No	Yes	No
Tajmir & Alkasab, 2018	Unclear	Yes	Yes	No	Yes	No
Tejani, 2020	Yes	Yes	Yes	No	Yes	No
Wood et al., 2019	Yes	Yes	Yes	No	Yes	No

Q1. Is the source of opinion clearly identified? Q2. Does the source of opinion have standing in the field of expertise? Q3. Are the interests of the relevant population the central focus of the opinion? Q4. Is the stated position the result of an analytical process, and is there logic in the opinion expressed? Q5. Is there reference to the extant literature? Q6. Is any incongruence with the literature/ sources logically defended?

More information about methodological assessments may be found in Tables 3 and 4.

Table 4 – Methodological quality of included studies (adapted from the JBI Critical Appraisal Checklist for Case Reports)

Checklist questions	Balthazar et al., 2019 (USA)	Lindqwister et al., 2020 (USA)	Wasserman et al., 2021 (USA)	Wiggins et al., 2020 (USA)
Were learner populations' demographic and social characteristics clearly described?	Yes	No	No	Yes
Was the learner population's history clearly described (considering the analyzed context)?	No	No	Yes	Yes
Was the current educational situation of the learners on the context clearly described?	Yes	No	Yes	Yes
Were assessment methods and the results clearly described (pre-intervention)?	Yes	Yes	Yes	Yes
Was the intervention(s) or procedure(s) / resource(s) (learning technology) or (learning model) clearly described?	Yes	Yes	Yes	Yes
Were the post-intervention outcomes clearly described?	Yes	Yes	No	Yes
Were unwanted or unanticipated events identified and described?	Yes	Yes	No	No
Does the experience report provide takeaway lessons?	Yes	Yes	No	Yes
Methodological Quality*	**High**	**Moderate**	**Moderate**	**High**

*Low quality: 1 to 3 "yes" answers; Moderate quality: 4 to 6 "yes" answers; High quality: 7 or 8 "yes" answers.

More information about methodological assessments may be found in Tables 3 and 4.

Appendix S1. Database Search.

Database	Search
Cochrane (Jul 26, 2021)	"artificial intelligence" OR "Computational Intelligence" OR "Machine Intelligence" OR "Computer Reasoning" OR "AI (Artificial Intelligence)" OR "Computer Vision Systems" OR "Computer Vision System" OR "Knowledge Acquisition (Computer)" OR "Knowledge Representation (Computer)" OR "Knowledge Representations (Computer)" OR "machine learning" OR "deep learning" OR "Computer Neural Network" OR "Computer Neural Networks" OR "Neural Network Model" OR "Neural Network Models" OR "Computational Neural Networks" OR "Computational Neural Network" OR "Perceptrons" OR "Perceptron" OR "Connectionist Models" OR "Connectionist Model" OR "Neural Networks (Computer)" OR "Neural Network (Computer)" OR "Ambient Intelligence" OR "Ambient Intelligences" OR "Ambient Assisted Living" OR "Ambient Assisted Livings" OR "Ambient-Assisted Living" OR "Ambient-Assisted Livings" OR "Heuristics" OR "computer heuristics" in Title Abstract Keyword AND "radiology" OR "diagnostic radiology" OR "radiography" OR "X-ray image" OR "X-ray diagnosis" OR "roentgenography" OR "X-ray" OR "radiodiagnosis" OR "x-ray analysis" in Title Abstract Keyword AND "education" OR "teaching" OR "Training Techniques" OR "Training Technique" OR "Training Technics" OR "Training Technic" OR "Pedagogy" OR "Pedagogies" OR "Teaching Methods" OR "Teaching Method" OR "Academic Training" OR "Training Activities" OR "Training Activity" OR "Educational Techniques" OR "Educational Technique" OR "Educational Technics" OR "Educational Technic" OR "Computer User Trainings" OR "Computer User Training" OR "Curriculum" OR "Curricula" OR "radiology education" OR "radiology residency" OR "computer interface" OR "human computer interaction" in Title Abstract Keyword - (Word variations have been searched)
Embase (Jul 26, 2021)	((((((('artificial intelligence':ti,ab,kw OR 'computational intelligence':ti,ab,kw OR 'machine intelligence':ti,ab,kw OR 'computer reasoning':ti,ab,kw OR ai:ti,ab,kw) AND 'artificial intelligence':ti,ab,kw OR 'computer vision systems':ti,ab,kw OR 'computer vision system':ti,ab,kw OR 'knowledge acquisition':ti,ab,kw) AND computer:ti,ab,kw OR 'knowledge representation':ti,ab,kw) AND computer:ti,ab,kw OR 'knowledge representations':ti,ab,kw) AND computer:ti,ab,kw OR 'machine learning':ti,ab,kw OR 'deep learning':ti,ab,kw OR 'computer neural network':ti,ab,kw OR 'computer neural networks':ti,ab,kw OR 'neural network model':ti,ab,kw OR 'neural network models':ti,ab,kw OR 'computational neural networks':ti,ab,kw OR 'computational neural network':ti,ab,kw OR 'perceptrons':ti,ab,kw OR 'perceptron':ti,ab,kw OR 'connectionist models':ti,ab,kw OR 'connectionist model':ti,ab,kw OR 'neural networks':ti,ab,kw) AND computer:ti,ab,kw OR 'neural network':ti,ab,kw) AND computer:ti,ab,kw OR 'ambient intelligence':ti,ab,kw OR 'ambient intelligences':ti,ab,kw OR 'ambient assisted living':ti,ab,kw OR 'ambient assisted livings':ti,ab,kw OR 'ambient-assisted living':ti,ab,kw OR 'ambient-assisted livings':ti,ab,kw OR 'heuristics':ti,ab,kw OR 'computer heuristics':ti,ab,kw) AND ('radiology':ti,ab,kw OR 'diagnostic radiology':ti,ab,kw OR 'radiography':ti,ab,kw OR 'x-ray image':ti,ab,kw OR 'x-ray diagnosis':ti,ab,kw OR 'roentgenography':ti,ab,kw OR 'x-ray':ti,ab,kw OR 'radiodiagnosis':ti,ab,kw OR 'x-ray analysis':ti,ab,kw) AND

	('education':ti,ab,kw OR 'teaching':ti,ab,kw OR 'training techniques':ti,ab,kw OR 'training technique':ti,ab,kw OR 'training technics':ti,ab,kw OR 'training technic':ti,ab,kw OR 'pedagogy':ti,ab,kw OR 'pedagogies':ti,ab,kw OR 'teaching methods':ti,ab,kw OR 'teaching method':ti,ab,kw OR 'academic training':ti,ab,kw OR 'training activities':ti,ab,kw OR 'training activity':ti,ab,kw OR 'educational techniques':ti,ab,kw OR 'educational technique':ti,ab,kw OR 'educational technics':ti,ab,kw OR 'educational technic':ti,ab,kw OR 'computer user trainings':ti,ab,kw OR 'computer user training':ti,ab,kw OR 'curriculum':ti,ab,kw OR 'curricula':ti,ab,kw OR 'radiology education':ti,ab,kw OR 'radiology residency':ti,ab,kw OR 'computer interface':ti,ab,kw OR 'human computer interaction':ti,ab,kw)
ERIC (Sep, 12, 2021)	"artificial intelligence" AND "radiology" AND "education"
Lilacs (Jul 26, 2021)	("Inteligência Artificial" OR "Artificial Intelligence" OR "Inteligencia Artificial" OR "Aquisição de Conhecimento (Computador)" OR "Aquisição de Conhecimentos (Informática)" OR "IA (Inteligência Artificial)" OR "Inteligência de Máquina" OR "Raciocínio Automático" OR "Raciocínio Computacional" OR "Representação de Conhecimento (Computador)" OR "Representação do Conhecimento (Computador)" OR "Sistemas de Visão Artificial" OR "Sistemas de Visão Computacional" OR "Aprendizado de Máquina" OR "Machine Learning" OR "Aprendizaje Automático" OR "Aprendizado Automático" OR "Aprendizado de Transferência" OR "Aprendizagem Automática" OR "Aprendizagem de Máquina" OR "Aprendizagem de Transferência" OR "Aprendizado Profundo" OR "Deep Learning" OR "Aprendizaje Profundo" OR "Aprendizado Estruturado Profundo" OR "Aprendizado Hierárquico" OR "Aprendizado de Máquina Supervisionado" OR "Supervised Machine Learning" OR "Aprendizaje Automático Supervisado" OR "Aprendizado Indutivo de Máquina" OR "Aprendizado Semi-Supervisionado" OR "Aprendizado Supervisionado de Máquina" OR "Aprendizado com Dados Rotulados" OR "Aprendizagem Semi-Supervisionada" OR "Aprendizagem Supervisionada de Máquina" OR "Aprendizagem de Máquina Supervisionada" OR "Aprendizagem de Máquina com Professor" OR "AI (Artificial Intelligence)" OR "Acquisition, Knowledge (Computer)" OR "Computational Intelligence" OR "Computer Reasoning" OR "Computer Vision System" OR "Computer Vision Systems" OR "Intelligence, Artificial" OR "Intelligence, Computational" OR "Intelligence, Machine" OR "Knowledge Acquisition (Computer)" OR "Knowledge Representation (Computer)" OR "Knowledge Representations (Computer)" OR "Machine Intelligence" OR "Reasoning, Computer" OR "Representation, Knowledge (Computer)" OR "System, Computer Vision" OR "Systems, Computer Vision" OR "Vision System, Computer" OR "Vision Systems, Computer" OR "Heuristics" OR "Adquisición de Conocimientos (Computador)" OR "Adquisición de Conocimientos (Informática)" OR "Adquisición de Conocimientos (Ordenador)" OR "IA (Inteligencia Artificial)" OR "Inteligencia de Máquina" OR "Razonamiento Automático" OR "Razonamiento Computacional" OR "Representación del Conocimiento (Computador)" OR "Sistemas de Visión Artificial" OR "Sistemas de Visión Computacional" OR "Sistemas de Visión por Computador" OR "Sistemas de Visión por Computadora" OR "Sistemas de Visión por Ordenador" OR "Heurística" OR "Aprendizaje por Transferencia" OR "Aprendizaje Jerarquizado" OR "Learning, Machine" OR "Learning, Transfer" OR "Transfer Learning" OR "Hierarchical Learning" OR "Learning, Deep" OR "Learning, Hierarchical") AND ("Radiography" OR "Radiografía" OR "Radiografia" OR "Diagnostic X Ray" OR "Diagnostic X Ray Radiology" OR "Diagnostic X-Ray" OR "Diagnostic X-Ray Radiology" OR "Diagnostic X-Rays" OR "Radiology, Diagnostic X Ray" OR "Radiology, Diagnostic X-Ray" OR

	"Roentgenography" OR "X Ray Radiology, Diagnostic" OR "X Ray, Diagnostic" OR "X-Ray Radiology, Diagnostic" OR "X-Ray, Diagnostic" OR "X-Rays, Diagnostic" OR "Radiographic Image Interpretation, Computer-Assisted" OR "Interpretación de Imagen Radiográfica Asistida por Computador" OR "Interpretação de Imagem Radiográfica Assistida por Computador" OR "Computer Assisted Radiographic Image Interpretation" OR "Computer-Assisted Radiographic Image Interpretation" OR "Radiographic Image Interpretation, Computer Assisted" OR "Diagnóstico Radiológico por Rayos X" OR "Diagnóstico por Rayos X" OR "Roentgenografía" OR "Interpretación de Imagen Radiográfica Asistida por Computadora" OR "Interpretación de Imagen Radiográfica Asistida por Ordenador" OR "Diagnóstico Radiológico por Raios X" OR "Diagnóstico por Raios X" OR "Roentgenografia") AND ("educação" OR "education" OR "educación" OR "capacitação" OR "currículo" OR "ensino" OR "Ensino" OR "Teaching" OR "Enseñanza" OR "Atividade de Treinamento" OR "Atividades Formativas" OR "Atividades de Capacitação" OR "Atividades de Formação" OR "Atividades de Treinamento" OR "Atividades de Treino" OR "Capacitação Acadêmica" OR "Didática" OR "Docência" OR "Formação Acadêmica" OR "Método de Ensino" OR "Métodos Pedagógicos" OR "Métodos de Ensino" OR "Pedagogia" OR "Treinamento Acadêmica" OR "Treino Acadêmico" OR "Técnica de Treinamento" OR "Técnicas Educacionais" OR "Técnicas Educativas" OR "Técnicas de Ensino" OR "Técnicas de Formação" OR "Técnicas de Treinamento" OR "Técnicas de Treino")
Livivo (Jul 26, 2021)	KW=("artificial intelligence" OR "Computational Intelligence" OR "Machine Intelligence" OR "Computer Reasoning" OR "AI (Artificial Intelligence)" OR "Computer Vision Systems" OR "Computer Vision System" OR "Knowledge Acquisition Computer" OR "Knowledge Representation Computer" OR "Knowledge Representations Computer" OR "machine learning" OR "deep learning" OR "Computer Neural Network" OR "Computer Neural Networks" OR "Neural Network Model" OR "Neural Network Models" OR "Computational Neural Networks" OR "Computational Neural Network" OR "Perceptrons" OR "Perceptron" OR "Connectionist Models" OR "Connectionist Model" OR "Neural Networks Computer" OR "Neural Network Computer" OR "Ambient Intelligence" OR "Ambient Intelligences" OR "Ambient Assisted Living" OR "Ambient Assisted Livings" OR "Ambient-Assisted Living" OR "Ambient-Assisted Livings" OR "Heuristics" OR "computer heuristics") AND KW=("radiology" OR "diagnostic radiology" OR "radiography" OR "X-ray image" OR "X-ray diagnosis" OR "roentgenography" OR "X-ray" OR "radiodiagnosis" OR "x-ray analysis") AND KW=("education" OR "teaching" OR "Training Techniques" OR "Training Technique" OR "Training Technics" OR "Training Technic" OR "Pedagogy" OR "Pedagogies" OR "Teaching Methods" OR "Teaching Method" OR "Academic Training" OR "Training Activities" OR "Training Activity" OR "Educational Techniques" OR "Educational Technique" OR "Educational Technics" OR "Educational Technic" OR "Computer User Trainings" OR "Computer User Training" OR "Curriculum" OR "Curricula" OR "radiology education" OR "radiology residency" OR "computer interface" OR "human computer interaction")
Pubmed (Jul 26, 2021)	(("artificial intelligence" OR "Intelligence, Artificial" OR "Computational Intelligence" OR "Intelligence, Computational" OR "Machine Intelligence" OR "Intelligence, Machine" OR "Computer Reasoning" OR "Reasoning, Computer" OR "AI (Artificial Intelligence)" OR "Computer Vision Systems" OR "Computer Vision System" OR "System, Computer Vision" OR "Systems, Computer Vision" OR "Vision System, Computer" OR "Vision Systems,

	Computer" OR "Knowledge Acquisition (Computer)" OR "Acquisition, Knowledge (Computer)" OR "Knowledge Representation (Computer)" OR "Knowledge Representations (Computer)" OR "Representation, Knowledge (Computer)" OR "machine learning" OR "deep learning" OR "Neural Networks, Computer" OR "Computer Neural Network" OR "Computer Neural Networks" OR "Network, Computer Neural" OR "Networks, Computer Neural" OR "Neural Network, Computer" OR "Models, Neural Network" OR "Model, Neural Network" OR "Network Model, Neural" OR "Network Models, Neural" OR "Neural Network Model" OR "Neural Network Models" OR "Computational Neural Networks" OR "Computational Neural Network" OR "Network, Computational Neural" OR "Networks, Computational Neural" OR "Neural Network, Computational" OR "Neural Networks, Computational" OR "Perceptrons" OR "Perceptron" OR "Connectionist Models" OR "Connectionist Model" OR "Model, Connectionist" OR "Models, Connectionist" OR "Neural Networks (Computer)" OR "Network, Neural (Computer)" OR "Networks, Neural (Computer)" OR "Neural Network (Computer)" OR "Ambient Intelligence" OR "Ambient Intelligences" OR "Intelligence, Ambient" OR "Intelligences, Ambient" OR "Ambient Assisted Living" OR "Ambient Assisted Livings" OR "Assisted Living, Ambient" OR "Assisted Livings, Ambient" OR "Living, Ambient Assisted" OR "Livings, Ambient Assisted" OR "Ambient-Assisted Living" OR "Ambient-Assisted Livings" OR "Living, Ambient-Assisted" OR "Livings, Ambient-Assisted" OR "Heuristics" OR "computer heuristics") AND ("radiology" OR "diagnostic radiology" OR "radiography" OR "X-ray image" OR "X-ray diagnosis" OR "roentgenography" OR "X-ray" OR "radiodiagnosis" OR "x-ray analysis")) AND ("education" OR "teaching" OR "Training Techniques" OR "Training Technique" OR "Technique, Training" OR "Techniques, Training" OR "Training Technics" OR "Technic, Training" OR "Technics, Training" OR "Training Technic" OR "Pedagogy" OR "Pedagogies" OR "Teaching Methods" OR "Teaching Method" OR "Method, Teaching" OR "Methods, Teaching" OR "Academic Training" OR "Training, Academic" OR "Training Activities" OR "Training Activity" OR "Activities, Training" OR "Activity, Training" OR "Techniques, Educational" OR "Educational Techniques" OR "Educational Technique" OR "Technique, Educational" OR "Educational Technics" OR "Educational Technic" OR "Technic, Educational" OR "Technics, Educational" OR "Computer User Trainings" OR "Training, Computer User" OR "Trainings, Computer User" OR "User Training, Computer" OR "User Trainings, Computer" OR "Curriculum" OR "Curricula" OR "radiology education" OR" radiology residency" OR "computer interface" OR "human computer interaction")
Scopus (Jul 26, 2021)	(TITLE-ABS-KEY ("artificial intelligence" OR "Computational Intelligence" OR "Machine Intelligence" OR "Computer Reasoning" OR "AI (Artificial Intelligence)" OR "Computer Vision Systems" OR "Computer Vision System" OR "Knowledge Acquisition (Computer)" OR "Knowledge Representation (Computer)" OR "Knowledge Representations (Computer)" OR "machine learning" OR "deep learning" OR "Computer Neural Network" OR "Computer Neural Networks" OR "Neural Network Model" OR "Neural Network Models" OR "Computational Neural Networks" OR "Computational Neural Network" OR "Perceptrons" OR "Perceptron" OR "Connectionist Models" OR "Connectionist Model" OR "Neural Networks (Computer)" OR "Neural Network (Computer)" OR "Ambient Intelligence" OR "Ambient Intelligences" OR "Ambient Assisted Living" OR "Ambient Assisted Livings" OR "Ambient-Assisted

	Living" OR "Ambient-Assisted Livings" OR "Heuristics" OR "computer heuristics") AND TITLE-ABS-KEY ("radiology" OR "diagnostic radiology" OR "radiography" OR "X-ray image" OR "X-ray diagnosis" OR "roentgenography" OR "X-ray" OR "radiodiagnosis" OR "x-ray analysis") AND TITLE-ABS-KEY ("education" OR "teaching" OR "Training Techniques" OR "Training Technique" OR "Training Technics" OR "Training Technic" OR "Pedagogy" OR "Pedagogies" OR "Teaching Methods" OR "Teaching Method" OR "Academic Training" OR "Training Activities" OR "Training Activity" OR "Educational Techniques" OR "Educational Technique" OR "Educational Technics" OR "Educational Technic" OR "Computer User Trainings" OR "Computer User Training" OR "Curriculum" OR "Curricula" OR "radiology education" OR "radiology residency" OR "computer interface" OR "human computer interaction"))
Web of Science (Jul 26, 2021)	"artificial intelligence" OR "Computational Intelligence" OR "Machine Intelligence" OR "Computer Reasoning" OR "AI (Artificial Intelligence)" OR "Computer Vision Systems" OR "Computer Vision System" OR "Knowledge Acquisition (Computer)" OR "Knowledge Representation (Computer)" OR "Knowledge Representations (Computer)" OR "machine learning" OR "deep learning" OR "Computer Neural Network" OR "Computer Neural Networks" OR "Neural Network Model" OR "Neural Network Models" OR "Computational Neural Networks" OR "Computational Neural Network" OR "Perceptrons" OR "Perceptron" OR "Connectionist Models" OR "Connectionist Model" OR "Neural Networks (Computer)" OR "Neural Network (Computer)" OR "Ambient Intelligence" OR "Ambient Intelligences" OR "Ambient Assisted Living" OR "Ambient Assisted Livings" OR "Ambient-Assisted Living" OR "Ambient-Assisted Livings" OR "Heuristics" OR "computer heuristics" (All Fields) and "radiology" OR "diagnostic radiology" OR "radiography" OR "X-ray image" OR "X-ray diagnosis" OR "roentgenography" OR "X-ray" OR "radiodiagnosis" OR "x-ray analysis" (All Fields) and "education" OR "teaching" OR "Training Techniques" OR "Training Technique" OR "Training Technics" OR "Training Technic" OR "Pedagogy" OR "Pedagogies" OR "Teaching Methods" OR "Teaching Method" OR "Academic Training" OR "Training Activities" OR "Training Activity" OR "Educational Techniques" OR "Educational Technique" OR "Educational Technics" OR "Educational Technic" OR "Computer User Trainings" OR "Computer User Training" OR "Curriculum" OR "Curricula" OR "radiology education" OR "radiology residency" OR "computer interface" OR "human computer interaction"
Google Scholar (Sep 12, 2021)	"artificial intelligence" AND "radiology" AND "education"

Open Grey (Jul 26, 2021)	("artificial intelligence" OR "Computational Intelligence" OR "Machine Intelligence" OR "Computer Reasoning" OR "AI (Artificial Intelligence)" OR "Computer Vision Systems" OR "Computer Vision System" OR "Knowledge Acquisition (Computer)" OR "Knowledge Representation (Computer)" OR "Knowledge Representations (Computer)" OR "machine learning" OR "deep learning" OR "Computer Neural Network" OR "Computer Neural Networks" OR "Neural Network Model" OR "Neural Network Models" OR "Computational Neural Networks" OR "Computational Neural Network" OR "Perceptrons" OR "Perceptron" OR "Connectionist Models" OR "Connectionist Model" OR "Neural Networks (Computer)" OR "Neural Network (Computer)" OR "Ambient Intelligence" OR "Ambient Intelligences" OR "Ambient Assisted Living" OR "Ambient Assisted Livings" OR "Ambient-Assisted Living" OR "Ambient-Assisted Livings" OR "Heuristics" OR "computer heuristics") AND ("radiology" OR "diagnostic radiology" OR "radiography" OR "X-ray image" OR "X-ray diagnosis" OR "roentgenography" OR "X-ray" OR "radiodiagnosis" OR "x-ray analysis") AND ("education" OR "teaching" OR "Training Techniques" OR "Training Technique" OR "Training Technics" OR "Training Technic" OR "Pedagogy" OR "Pedagogies" OR "Teaching Methods" OR "Teaching Method" OR "Academic Training" OR "Training Activities" OR "Training Activity" OR "Educational Techniques" OR "Educational Technique" OR "Educational Technics" OR "Educational Technic" OR "Computer User Trainings" OR "Computer User Training" OR "Curriculum" OR "Curricula" OR "radiology education" OR "radiology residency" OR "computer interface" OR "human computer interaction")
ProQuest (Jul 26, 2021)	noft("artificial intelligence" OR "Computational Intelligence" OR "Machine Intelligence" OR "Computer Reasoning" OR "AI (Artificial Intelligence)" OR "Computer Vision Systems" OR "Computer Vision System" OR "Knowledge Acquisition (Computer)" OR "Knowledge Representation (Computer)" OR "Knowledge Representations (Computer)" OR "machine learning" OR "deep learning" OR "Computer Neural Network" OR "Computer Neural Networks" OR "Neural Network Model" OR "Neural Network Models" OR "Computational Neural Networks" OR "Computational Neural Network" OR "Perceptrons" OR "Perceptron" OR "Connectionist Models" OR "Connectionist Model" OR "Neural Networks (Computer)" OR "Neural Network (Computer)" OR "Ambient Intelligence" OR "Ambient Intelligences" OR "Ambient Assisted Living" OR "Ambient Assisted Livings" OR "Ambient-Assisted Living" OR "Ambient-Assisted Livings" OR "Heuristics" OR "computer heuristics") AND noft("radiology" OR "diagnostic radiology" OR "radiography" OR "X-ray image" OR "X-ray diagnosis" OR "roentgenography" OR "X-ray" OR "radiodiagnosis" OR "x-ray analysis") AND noft("education" OR "teaching" OR "Training Techniques" OR "Training Technique" OR "Training Technics" OR "Training Technic" OR "Pedagogy" OR "Pedagogies" OR "Teaching Methods" OR "Teaching Method" OR "Academic Training" OR "Training Activities" OR "Training Activity" OR "Educational Techniques" OR "Educational Technique" OR "Educational Technics" OR "Educational Technic" OR "Computer User Trainings" OR "Computer User Training" OR "Curriculum" OR "Curricula" OR "radiology education" OR "radiology residency" OR "computer interface" OR "human computer interaction")

Appendix S2. Excluded articles and reason for exclusion. (n=23).

Author, year (Databases)	Reason for exclusion
Allen et al., 2019(Allen et al. 2019)	1
Awan et al., 2019(Awan et al. 2019)	2
Bhardwaj, 2019(Bhardwaj 2019)	1
Chen et al., 2018(Chen et al. 2019)	2
Deng, 2020(Deng 2020)	2
Gallix & Chong, 2019(Gallix and Chong 2019)	3
Jha et al., 2018(Jha and Topol 2018)	1
Kobayashi et al., 2019(Kobayashi et al. 2019)	1
Little, 2021(Little 2021)	2
Lo et al., 2020(Lo and Awan 2020)	1
Macura & Macura, 1995(Macura and Macura 1995)	4
Mcmillan, 2020(McMillan 2020)	1
Richardson et al., 2021(Richardson et al. 2021)	2
Rodríguez et al., 2016(Rodríguez et al. 2016)	1
SFR-IA Group; CERF; French Radiology Community, 2018(SFR-IA Group; CERF. 2018)	1
Sharples et al., 1989(Sharples et al. 1989)	4
Slanetz, 2018(Slanetz 2018)	1
Weisberg et al., 2020(Weisberg and Fishman 2020)	3
Zanca et al., 2021(Zanca et al.)	1

Author, year (Grey Literature)	Reason for exclusion
Buyuk, 2021(Buyuk 2021)	3
Pianykh et al., 2020(Pianykh et al. 2020)	1
Shaffer, 2005(Shaffer 2005)	1
Solomon et al., 2020(Solomon et al. 2020)	1

1. Studies in which diagnostic radiology curriculum and artificial intelligence use is not the main focus; 2. Studies that describe or comment artificial intelligence educational tools; 3. Studies focused on students or professionals' perception of artificial intelligence use in radiology and 4. Book or book chapter.

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CAPÍTULO 5

RADIOMICS IN BONE PATHOLOGY OF THE JAWS: A SYSTEMATIC REVIEW

Short title: Radiomics in jaw pathologies: a systematic review.

Affiliations
Glaucia N M Santos a, *, MSC, DDs, Msc
a Dentistry Department, Faculty of Health Science, University of Brasília, Brasilia, Brazil. E-mail:
nize.gal@gmail.com ORCID: https://orcid.org/0000-0002-9955-4323
Helbert E C da Silva a, DDs, Msc
a Dentistry Department, Faculty of Health Science, University of Brasília, Brasilia, Brazil. E-mail:
helbertcardososilva@gmail.com ORCID: https://orcid.org/0000-0003-2662-6987
Filipe E L Ossege b, DDs, Msc
b Mechanical Engineering Department, Faculty of Technology, University of Brasília, Brasília, Brazil. E-mail: eduard.ossege@gmail.com ORCID: https://orcid.org/0000-0002-9858-6825
Paulo Tadeu de S Figueiredo a, DDs, Msc, PhD
a Dentistry Department, Faculty of Health Science, University of Brasília, Brasilia, Brazil. E-mail:
paulofigueiredo@unb.br ORCID: https://orcid.org/0000-0002-7285-7869
Nilce de Santos Melo a, DDs, Msc, PhD
a Dentistry Department, Faculty of Health Science, University of Brasília, Brasilia, Brazil. E-mail:
nilce@unb.br ORCID: https://orcid.org/0000-0001-7268-485X
Cristine Miron Stefani a, DDs, Msc, PhD
a Dentistry Department, Faculty of Health Science, University of Brasília, Brasilia, Brazil. E-mail:
cmstefani@gmail.com ORCID: https://orcid.org/0000-0003-4712-9779
André Ferreira Leite a, DDs, Msc, PhD
a Dentistry Department, Faculty of Health Science, University of Brasília, Brasilia, Brazil. E-mail:andreleite@unb.br ORCID: https://orcid.org/0000-0002-7803-4740

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*Corresponding author:

Glaucia Nize Martins Santos
University of Brasília - Setor de Grandes Áreas Norte 605 - Post Code: 70840-901– Asa Norte, Brasília, DF, Brazil Tel: + 55 61 99113-8119 nize.gal@gmail.com

ABSTRACT

Objective: To define which are and how the radiomics features of jawbone pathologies are extracted for diagnosis, predicting prognosis and therapeutic response.

Methods: A comprehensive literature search was conducted using eight databases and gray literature. Two independent observers rated these articles according to exclusion and inclusion criteria. 23 papers were included to assess the radiomics features related to jawbone pathologies. Included studies were evaluated by using JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies.

Results: Agnostic features were mined from periapical, dental panoramic radiographs, Cone Beam CT, CT and MRI images of six different jawbone alterations. The most frequent features mined were texture-, shaped- and intensity-based features. Only 13 studies described the machine learning step, and the best results were obtained with Support Vector Machine and random forest classifier. For osteoporosis diagnosis and classification, filtering, shaped-based and Tamura texture features showed the best performance. For temporomandibular joint pathology, Gray-Level Co-occurrence Matrix (GLCM), Gray-Level Run-Length Matrix (GLRLM), (Gray-Level Size Zone Matrix (GLSZM), first-order statistics analysis and shaped-based analysis showed the best results. Considering odontogenic and non-odontogenic cysts and tumors, contourlet and SPHARM features, first-order statistical features, GLRLM, GLCM had better indexes. For odontogenic cysts and granulomas, first-order statistical analysis showed better classification results.

Conclusions**:** GLCM was the most frequent feature, followed by first-order statistics, and GLRLM features. No study reported predicting response, prognosis or therapeutic response, but instead disease diagnosis or classification. Although the lack of standardization in the

radiomics workflow of the included studies, texture analysis showed potential to contribute to radiologists' reports, decreasing the subjectivity and leading to personalized healthcare.

KEYWORDS: Radiomics; Jaws; Texture analysis; Bone; Systematic Review.

INTRODUCTION

Radiomics is the process of extracting quantitative information from radiological images, and is designed to develop decision support tools, taking a central role in the context of personalized precision medicine. Mining data from digital images and combine them with other patient characteristics promises to increase precision in diagnosis, assessment of prognosis, and prediction of therapy response[1–5].

Radiomic analyses begins with the choice of a high-quality imaging protocol. Such imaging methods include X-Ray, CT, MRI, Nuclear Medicine, Positron Emission Tomography and Ultrasound[3]. After a prediction target is well stablished, regions that may contain value information, the region of interest (ROI) or volume of interest (VOI), are identified from these images. Then, they are segmented manually or computer-aided, and quantitative features based on texture, shape and gray level statistics within images are extracted to generate a report, which can be combined with demographic, clinical or genomic information from a database. These data are then mined to develop diagnostic, predictive or prognostic models to outcomes of interest[1,3,5].

The main part of radiomics is the process of analyzing texture, also known as feature extraction[6], and it is classified in two types: semantic features, which are commonly used in radiologic evaluation, and agnostic or non-semantic features, which comprise quantitative descriptors that are mathematically extracted from radiologic images, grounded on shape, intensity, texture, and filtering information[1,3,4,7]. This stage produces a large number of radiomics features and only the "highly" informative ones are selected based on the user defined criteria, developing the so-called radiomics signature[2,3].

The concept of radiomics has most broadly been applied in the field of oncology[7], since digitally encrypted medical images hold information related to tumor pathophysiology, which can be transformed into mineable quantitative high-dimensional data[5]. Its potentials include the differential diagnosis between neoplasms, correlation with molecular biology and genomics, the prediction of survival and the evaluation of the response to treatment[8]. Many other medical specialties are benefiting from radiomics studies, such as neuroimaging, cardiac imaging, and gastroenterology[2]. Although the literature is still scarce in dentistry field, the possibilities and perspectives of the use of radiomics-based analyses combined with the oral radiologists' analyses are growing through the years. A review of the state-of-the-art of using radiomics and machine learning (ML) for imaging in oral healthcare was recently described, which showed image segmentation and optimization applications, and pathology detection, classification and diagnosis implementations[4].

Regarding jawbone alterations, it is challenging to differentiate imaging lesions within the maxilla and mandible due to the appearance similarity among a wide variety of pathologies, mainly lesions from odontogenic and osseous sources. The response of the cancellous and cortical bone to pathologic stimulus can be expressed by osteolytic or osteoblastic behavior. Thus, most lesions within the jaws are possibly classified as lytic, sclerotic, or a mixture of both[9–11]. Due to this large scenario of the dentomaxillofacial imaging, the goal of this study is to define which are the radiomics features of bone pathologic alterations of the jaws and how they are extracted for diagnosis, predicting prognosis and therapeutic response. In this systematic review, radiomics workflow with emphasis in feature analysis was investigated related to bone changes of the jaws.

METHODS

Study Design

A systematic review that analyzed radiomics features was performed to answer the question: "In dentomaxillofacial imaging, which are the radiomics features of bone pathologic changes of the jaws and how are they extracted for diagnosis, predicting prognosis and therapeutic response?"

Eligibility Criteria

PFO (Participants, Factors and Outcomes) acronym was used to define inclusion and exclusion criteria. As inclusion criteria, dentomaxillofacial imaging of bone alterations of the jaws (P) and Radiomics analysis (F) were evaluated. Lastly, the outcomes measured (O) were feature extraction and their usefulness in detecting or classifying bone alterations of the jaws (sensitivity, specificity, ROC, AUC).

Inclusion criteria:

All published studies using radiomics in bone pathologic changes of the jaws, that reported partially or completely the radiomics workflow, including feature extraction parameters.

Exclusion criteria:

The following exclusion criteria were applied:

1. Reviews, editorials, letters, personal opinions, book chapters and conference abstracts;
2. Ultrasound imaging and elastography applied to the maxillofacial region;
3. Scanned images;
4. Non- human studies;
5. Maxillofacial trauma, peripheric lesions with bone destruction, anatomic variations, metastatic lesions and abnormalities.
6. Testing cases not based in imaging exams;

7. Studies that merely differentiated healthy from pathological areas.

Information Sources and Search Strategy

Individual search strategies for each of the following bibliographic databases were developed: Embase, IEEE Xplore, Lilacs, Livivo, PubMed, Science Direct, Scopus and Web of Science. The following terms ("Intraoral radiography" OR "Extraoral radiography" OR "Dental panoramic radiographs" OR "Cone Beam Computed Tomography" OR "Magnetic Resonance Image" OR "PET-CT Scan" OR "Multislice Computed Tomography") AND ("osseous pathology" OR "bone pathology") AND (Jaws OR "Mandibular bones" OR "Maxillary Bones" OR "Alveolar bone") AND (Radiomics OR "Texture Analysis" OR "feature extraction") and their synonyms were used to develop the search strategies. A gray literature search was taken using Google Scholar, JSTOR and ProQuest (Supplementary Material 1). The end search date was January 12, 2022 across all databases. Manual searches of reference lists were performed on relevant articles, theses and dissertations.

All references were managed by the software Mendeley®, Elsevier and duplicate records were removed.

Study Selection

The study selection was completed in two phases. In Phase I, two reviewers (GNMS and HECS) independently reviewed the titles and abstracts of all identified electronic database records. Those not meeting the inclusion criteria were discarded. In Phase II, the same reviewers applied the inclusion criteria to the full text of the articles. Both phases were completed using the Rayyan QCRI online application (https://rayyan.qcri.org). The references lists of selected studies were critically assessed by both examiners (GNMS and HECS). Any disagreement in first or second phase was solved by discussion until consensus between the two authors was attained. When a consensus was not reached, a third reviewer (FELO) was involved to make a final decision.

Data Collection Process and Data Items

One author (GNMS) collected the required data from the selected articles and a second author (HECS) cross-checked the collected information. Any disagreement was resolved by consensus or the third reviewer (FELO) decision. For each of the included studies, the following items were recorded: authors, year of publication, country, sample size, objective of the study, imaging modality and protocol, reference exam, image processing techniques, segmentation method, software used, extracted features, machine learning classification method, statistical results and main conclusions. In case of incomplete required data, attempts were made to contact the authors to retrieve any pertinent missing information.

The included studies were also assessed using the Radiomics Quality Score (RQS), proposed by Lambin et al. 2017[5], which consists of a homogeneous evaluation criteria and reporting guidelines for assessment of radiomic studies. It is composed by five main sections, namely Data selection, Medical Imaging, Feature extraction, Exploratory analysis, and Modeling, which include 16 criteria that carry different weights, such that a maximum of 36 points can be achieved. Full and clear reporting of information is required on all these aspects to minimize bias and enhance the usefulness of prediction models.

Methodological quality assessment of included studies

The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross-Sectional Studies[12] was applied as the methodological quality assessment. Regarding JBI quality appraisal, two reviewers (GNMS and HECS) scored the items as Yes, No, Unclear and Not Applicable for the included articles. Any disagreement was resolved by consensus or a third author (PTSF) decision.

Outcomes of Interest

Included manuscripts were synthesized in a qualitative and quantitative description focused on the following radiomics data: main objective, ROI/ VOI segmentation, software used, feature extraction, machine learning modeling/ classifier and their result rates.

Synthesis of results

A meta-analysis was planned since the data from the included studies were considered relatively homogeneous.

RESULTS

Study Selection

In Phase I, 508 studies were retrieved from the 8 electronic databases. Afterwards, duplicate articles were removed, resulting in 445 remaining studies. After, a comprehensive evaluation of titles and abstracts, 389 articles records were excluded. Therefore, 56 manuscripts were elected to conduct a full-text reading. Later, 35 studies were excluded, resulting in 21 studies at the end of Phase I from databases. From the reference lists of these 21 included studies, seven articles were selected to a full-text reading. Regarding the gray literature, 40 studies were retrieved from Google Scholar and one from ProQuest. No additional study was found across JSTOR.

After cautious evaluation of the 48 abstracts obtained from gray literature and the addition of the reference list results to them, 38 studies were discarded and 10 were assessed for full-text reading. Then, two studies were included. All the excluded articles and reasons for exclusion are described in Supplementary Material 2. Finally, 23 studies were selected for inclusion per study parameters (Figure 1).

Studies' Characteristics

The 23 included studies were published in seven different types of journals: biomedical computer science[13–16], biomedical physics and engineering[17–19], radiology[20–27], general engineering/ computer science/ physics[28–32], biomedical research[33], oral and maxillofacial surgery[34] and periodontology[35]. The studies were conducted in 12 different countries: Belgium[33], Brazil[29,35], China[23], Indonesia[15,31], Iran[13,17], Japan[21,22,26], Jordan[14,30], Korea[20,24], Poland[32], Turkey[16], the United Kingdom[19], and the United States of America[18,25,28,34]. All studies were published in english. Sample size ranged from 19[29] to 663[19] imaging exams. According to the exam modality, 10 studies used Cone Beam CT (CBCT)[13,16–18,23,28–30,34,35], four chose Helicoidal CT[21,22,25,26], Dental Panoramic Radiograph was applied in five studies[14,19,20,24,31], Periapical Images in one study[32] and two elected MRI[27,33]. One study used both Dental Panoramic Radiograph and Periapical Images[15]. Seven authors studied osteoporosis[14,15,19,20,24,25,30], four assessed temporomandibular joint (TMJ) pathology[17,28,33,34], one reported diabetes[22], three studies analyzed radicular cysts and granulomas[18,29,32], five authors studied odontogenic and non-odontogenic cysts and tumors[13,16,23,26,31], and three reported osseous inflammation/ infection[21,27,35]. A summary of the studies' descriptive characteristics can be found in Table 1.

Methodological Quality Assessment of Included Studies

All 23 studies were evaluated by using JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies[12]. The overall methodological assessment ranged from low quality: one to three "Yes" answers; moderate quality: four to six "Yes" answers or high quality: seven or eight "Yes" answers. Eight[13–15,18,24,30–32] studies presented moderate methodological quality while 13[19,20,34,35,21,23,25–29,33] studies showed high methodological quality. Two studies showed low methodological quality[16,17].

All studies measured the outcomes in a valid and reliable way and presented an appropriate statistical analysis. However, many selected studies presented methodological problems related to inclusion and exclusion selection criteria[13,14,32,15–19,24,30,31], subjects description[13,14,16–18,30,31,35], and standardized criteria used for measurement of the condition[13,14,16,17,24,31]. In three studies[16,17,31], the exposure was not measured in a valid and reliable way. More information about methodological assessment may be found in Supplementary Material 3.

Radiomics results

To answer the main question of this systematic review, the following characteristics were considered: main objective, image modality, segmentation, software used, features extracted, machine learning classifier and their result rates. The Radiomics Quality Score (RQS)[5] was assessed and the general result is showed in Figure 2. More detailed radiomics workflow of the included studies is presented in Table 2.

The main objectives of the included works were: a) recognize a specific disease or a pathologic pattern[15,17,28,30,34,35,19–25,27] or b) classify two or more similar diseases or pathologic patterns[13,14,16,21,24,26,29,31–33]. Most included studies used CBCT as imaging modality (43.4%), followed by the Dental Panoramic Radiography (26%). Also, the most tested diseases were osteoporosis (30.4%) and odontogenic and non-odontogenic cysts and tumors (21.7%). Manual and semi-automatic segmentations were reported in 86.3% of the studies, and automatic segmentation was also described.

Gray Level Co-occurrence Matrix (GLCM) was the most frequent statistical feature, described in 15 studies, followed by first-order statistics, described in 12 studies (histogram features in seven of them). Gray Level Run Length Matrix (GLRLM) were reported in seven studies, whereas 14 studies mined shaped-based features.

Only 13 (56.5%) authors described the machine learning classifier step. Most studies developed the machine learning classifier based on supervised learning Support Vector Machine (SVM) (61.5%) and random forest classifier (38.5%). For osteoporosis diagnosis and classification, filtering, shaped-based and Tamura texture features showed the best performance. For TMJ pathology, GLCM, GLRLM, Gray Level Size Zone Matrix (GLSZM) first-order statistics and shaped-based analyses showed the best results. Considering odontogenic and non-odontogenic cysts and tumors, contourlet and Spherical Harmonics (SPHARM), first-order statistical, GLRLM, GLCM had better indexes. For odontogenic cysts and granulomas, first-order statistical analysis showed better classification results.

1. Osteoporosis

All the seven[14,15,19,20,24,25,30] included studies that explored osteoporosis used the Dual energy X-ray Absorptiometry (DEXA) as the reference bone density exam. Four authors[14,19,20,24] chose Dental Panoramic Radiographs, one Dental Panoramic Radiographs with Periapical Radiographs[15], one non-contrast head CT[25] and one mandibular CBCT[30] to extract features. Manual or semi-automatic segmentation was applied in five studies, while automatic segmentation was performed in two studies[15,19]. The extracted features included histogram[14,25], filtering[24], GLCM[19,20,24,25], Gray Level Run Length (GLRL)[25], Gray Level Gradient Matrix (GLGM)[25], Law features[25] and Tamura features for 3D images[30]. Other morphological/ structure or shape features mined were the Mandibular Cortical Width (MCW)[19,24], Strut Analysis,[20] Fractal Dimension (FD)[19,20,24], thickness and roughness[24], shaped-based porous trabecular[14,15] and trabecular features[30].

The machine learning algorithms used were Learning Vector Quantization (LQV)[14], Decision Tree[15,20], SVM[20,24], Naïve Bayes[24], k-Nearest Neighbors (k-NN)[24], Back

Propagation Artificial Neural Networks (BPANN)[30], and random forest classifier[19]. One author[25] did not developed a model classifier.

The most expressive results were observed in osteoporosis level and osteoporosis diagnosis. Regarding osteoporosis level, accuracy of 92.6% was obtained using Gabor-based filter algorithm in SOM/ LVQ (Self-Organizing Map/ Learning Vector Quantization) method[14]; For osteoporosis diagnosis it was observed: accuracy of 96.25% using Strut variables in the endosteal margin area in Decision Tree and 96.9% in SVM methods[20]; accuracy of 96.8% using FD plus MCW in SVM classifier method[24]; accuracy of 97.917% using Tamura texture features in BPANN method[30] and accuracy of 73.33% using porosity feature in Decision Tree method[15]. Area Under the Curve (AUC) value for identifying osteoporosis at femoral neck was 0.872 using combined MCW and GLCM in random forest classifier method[19]. Moreover, an author[25] evaluated the texture features without machine learning classifier method, which demonstrated that 31 features had significant differences between normal bone mineral density (BMD) and osteoporosis in the left condyle and 22 features had a statistically significant difference in both sides of the condyle, being six histogram, three GLCM, nine GLRL, two GLGM and two Law features.

2. TMJ Pathology

Four studies intended to evaluate the diagnostic performance of radiomic features for TMJ, being two for osteoarthritis[28,34], and two for TMJ disorders[17,33]. Three[28,33,34] of them used the clinical parameters following the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) as the reference exam. CBCT was the imaging exam used in three studies[17,28,34] and MRI in one[33]. Manual segmentation was done in three studies[28,33,34], while one study did not mention how the segmentation was applied.[17] The radiomic features include first-order/ histogram of oriented gradients[17,33], shape[33], GLCM[28,33,34], GLRLM[28,33,34], and

GLSZM[33]. Also, semantic features including biomolecular features (proteins of serum and saliva)[28], clinical features (age, gender, signs and symptoms)[28,34], and imaging features (bone morphometry)[28,34], were correlated to radiomic analysis in two studies. The machine learning algorithms used were Logistic Regression[28,33], random forest classifier[17,28,33], Light Gradient Boosting Machine (LightGBM)[28], Extreme Gradient Boosting (XGBoost)[28,33], k-NN[17,33], SVM[17,33], Naïve Bayes[17], Decision Tree[33] and k-means clustering[33]. One author[34] did not developed any model classifier.

The best classifiers' results were: accuracy of 82.3% using clinical, protein information and radiomics features (GLCM, GLRLM and bone morphometry) in XG-Boost + LightGBM method[28], accuracy of 92.42% using first-order statistics analysis in k-NN classifier method[17] and AUC of 89% using shaped-based, first-order, GLCM, GLRLM and GLSZM analysis in k-NN method[33]. Without the classifier method, an author described a AUC ≥ 0.70 for energy and entropy features[34].

3. Odontogenic and non-odontogenic cysts and tumors

Five studies aimed to diagnose cysts[23], classify cysts[13,16] or to differentiate cysts from tumor lesions[26,31]. There were two standard comparators, histological exams[13,16,26] and surgical exploration[23]. One author[31] did not mention a reference exam. CBCT,[13,16,23] Dental Panoramic Radiography[31], and non-contrast CT[26] were the imaging exams explored. Manual segmentation was done in four studies[16,23,26,31], while automatic segmentation was performed in one study[13]. The mined radiomics features were edge- and region-based analysis (shape)[13], first order[16,23,26,31], GLCM[16,23,26,31], GLRLM[23,31], GLSZM[23], Neighboring Gray Tone Difference Matrix (NGTDM)[23], GLRL[26], GLGM[26], Law features[26], Chi-square features[26] and coutourlet[13]. Semantic features, such as volume, size, solidity and eccentricity[23], and region, tooth within the lesion, volume, septum[26], were also described. Only three authors[13,16,31] developed the machine learning model with the algorithms SVM[13,16,31], k-NN[16], Naïve Bayes[16], Decision Trees[16], random forest classifier[16] and Neural Network[16].

The most expressive results were: accuracy of 96.48% in classifying radicular cyst, dentigerous cyst and keratocysts, using a combination of contourlet and SPHARM features in Sparse Discriminant Analysis (SDA) classifier[13]; accuracy of 87.18% in differentiating cysts from tumors, using the combination of first-order statistical features and GLRLM; and 87.18% using the combination of first-order statistical features, GLCM and GLRLM, with SVM classifier[31]. The SVM classifier achieved the best classification performance in differentiating periapical cysts from keratocysts, with 100% accuracy after feature reduction based on first-order and GLCM features[16]. Analysing features without the classifier model, one author found that two semantic features (volume and size) were significantly different between the keratocyst and simple bone cyst groups. Among the texture features, GLCM contrast, NGTDM contrast, and GLCM variance had the highest correlation coefficients[23]. Another author reported that significant differences were obtained between dentigerous cyst and keratocyst by using Mann-Whitney's *U* test analysis, nine histogram features, one GLCM, three GLRL, four GLGM, two Law features, and two Chi-square features. Furthermore, four histogram and one Chi-square features showed significant differences between keratocyst and ameloblastoma, and two histogram features showed significant differences between dentigerous cyst and ameloblastoma[26].

4. Odontogenic cysts and granulomas

Three authors[18,29,32] proposed the differentiation between radicular cysts and granulomas. Two of them used CBCT images[18,29] and one Periapical Radiographs[32], which were compared to histology and clinical endodontics findings. Manual segmentation was applied in two studies[29,32], while semi-automatic segmentation was performed in one study[18].

The radiomics features were GLCM[29], histogram-based method[18,32], second-order features (14 Haralick features)[32], Run-Length Matrices (RLM),[32] Gray-Tone Difference Matrices (GTDM)[32] and Local Binary Patterns (LBP)[32]. One author used as semantic features age, gender, diameter, volume and tooth involved[29].

Two authors developed the machine learning models, in which the learning methods were the Linear Discriminant Analysis (LDA)-AdaBoost method[18], logistic regression[32], and 2D and 3D t-Distributed Stochastic Neighbor Embedding (t-SNE) models[32].

The best results were: accuracy of 94.1% in classifying radicular periapical cysts and granulomas, using first-order statistical analysis in LDA-AdaBoost classifier[18], and the best predictor variable was YS6GlcmZ4Entropy texture in logistic regression method[32]. Without machine learning classifier model, one author described five parameters (angular second moment, sum of squares, sum of average, correlation and contrast) which were selected due to their potential to differentiate periapical cysts from granulomas based on their sensitivity and specificity, as they achieved the AUC of 81.2% in the validation set[29].

5. Bone inflammation/ infection

One author proposed to detect patients with grade C periodontitis using CBCT[35], one to detect stage 0 Medication-related Osteonecrosis of the Jaw (MRONJ) using CT[21] and another to early diagnose of suppurative osteomyelitis using MRI[27]. All of them applied manual segmentation and no machine learning model was developed. The radiomics features were GLCM[27,35], GLRLM[21], GLZLM[21] and histogram feature[27].

Comparisons between periodontal disease groups showed statistically significant differences for all parameters. In the intergroup of periodontitis level analysis, there were statistically significant differences in the following parameters: inverse difference moment, angular second moment, entropy, sum of average, sum of variance, sum of entropy, difference of variance and difference of entropy[35].

Among 37 texture features, the bone marrow of the mandible with stage 0 MRONJ and the contralateral normal mandibular bone marrow revealed significant differences in six GLRLM and four GLZLM features. Moreover, these texture features exhibited a moderate diagnostic performance[21].

Finally, the histogram feature and the eight GLCM features in the acute osteomyelitis group were significantly higher than in the non-osteomyelitis group.[27]

6. Diabetes Mellitus

One author[22] proposed the assessment of the mandibular condylar bone marrow in diabetes mellitus using CT. The reference exam was defined as HbA1c≥6.5% on blood test. Manual segmentation was performed and the radiomics features selected were histogram feature, GLRLM, GLCM, and wavelets. No machine learning model was developed. One histogram feature, 15 GLCM features, and four GLRLM features showed significant differences between the diabetes and control patients.

Quantitative Synthesis and Evidence Certainty

The selected studies were all descriptive and used similar methods, which reduced the possibility of misinterpretation. Results were considered homogeneous enough but did not have compatible quantitative data to run a meta-analysis.

Due to the qualitative nature of included studies, an analysis of the certainty of evidence was not performed.

DISCUSSION

This is the first systematic review that discussed which are the texture features of bone pathologic changes of the jaws and how they are extracted for diagnosis, predicting prognosis and therapeutic response in dentomaxillofacial imaging. According to the obtained results, agnostic features based on shape, intensity, texture and filtering information were mined from Periapical, Dental Panoramic Radiographs, CBCT, Helicoidal CT and MRI images. Six different jawbone alterations were studied: osteoporosis, TMJ pathology, diabetes, radicular cysts and granulomas, odontogenic and non-odontogenic cysts and tumors, and osseous inflammation/ infection. No study reported predicting response, prognosis or therapeutic response, but instead diagnosis or classification of the aforementioned diseases. The small number of included articles and their main objective are in agreement with a previous meta-analysis[8], which highlighted that 91% of radiomics studies concern oncological applications, and 81% of them are for diagnostic purposes. This systematic review pointed out the potentials and also the limitations of the previous published studies, including the variability of imaging techniques and protocols.

The literature recognizes the importance of using standardized imaging protocols to eliminate unnecessary confounding variability when dealing with radiomics, including scanner manufacturer, model and calibrations. Different results may arise when diverse filters and thresholding are used[1,36]. From the different imaging modalities employed in the included studies, a wide range of protocols settings were applied. Some studies have not reported the acquisition protocol. Software variability may also lead to different results even when a feature is measured from the same ROI/ VOI obtained from identical scans[36]. From the included studies, six authors[15,16,20,24–26] used in-house developed software, without providing further details, and three authors[14,17,19] did not even cited which software was used. In addition, JPEG and BMP images formats were used instead of DICOM in two included studies[29,32]. To facilitate inter-operability of radiomic features and make standardization available, differences in algorithms and software implementations should be elucidated by using open-source software or releasing source code publicly[5,36].

Another crucial step related to radiomics is the segmentation of the analyzed structures. The majority of the included studies employed manual or semi-automatic segmentation. A previous work pointed out that manual outlining by experts is considered the ground truth in tumor segmentation, although its result can be unreliable due to inter- and intraobserver segmentation variability[37]. On the other hand, some authors assured that automatic and semiautomatic segmentation methods are preferred due to their robustness and significantly higher levels of reproducibility, with minimum user input[38].

According to this review result, first statistical and GLCM second statistical-based techniques were the most mined feature algorithms, which corroborates with previous literature[3,39]. In a statistical-based model, first-order statistics evaluate the gray-level frequency distribution from the pixel/ voxel intensity histogram in a given area of interest, while GLCM captures spatial relationships of pairs of pixels/ voxels with predefined gray-level intensities, in different directions (horizontal, vertical, or diagonal for a 2D analysis or 13 directions for a 3D analysis), with a predefined distance between them[40]. Regarding the machine learning model development, SVM and random forest were the most applied classifiers in this review. An author highlighted that SVM was one of the first highly successful models, although required a careful feature selection[41]. Also, a previous study compared 12 supervised classifiers in predicting overall survival in lung cancer patients, with CT images and found the random forest classifier as the best performance method[38]. Since radiomics is a new and expanding area of research, better classification algorithms will be developed, so that the optimal method is not yet clearly defined and will depend on the application[3].

As explained, radiomics studies involve multiple complex subprocesses each one affected by a wide range of decisions, and a sort of software and mathematical approaches to segmentation, texture mining and statistical analysis[5,36,42]. According to this review results, there is no consensus about the selection of proper texture features that could be relevant in diagnosis of pathological changes of the jaws. In particular, many textural indices show a lack of reproducibility and standardization, an obstacle also reported by other studies[1,5,7,36], including a phantom experiment[42]. These aspects are specially related to the deficiency of imaging protocol standardization in retrospective study designs, poor calibration statistics and restricted source code and data, as observed in the included articles of this review by means of the Radiomics Quality Score (RQS) proposed by Lambin et al.[5]. The cut-off values were often arbitrarily chosen, a practice previously criticized[7], which may lead to biased validation. This also may increase the risk of false-positive results and consequently delays the translation to clinical practice[43]. Furthermore, radiomics studies based on retrospectively collected data have low level of evidence because imaging protocols, including acquisition, and reconstruction settings are often not controlled or standardized, and they mainly serve as examples[7]. The solution would include imaging protocols standardization, development of generalizable models and larger samples. Multicentric efforts are required, since data-sharing enables initiation of highly powered prospective studies and accelerates the development and validation of radiomic signatures derived from new and existing data[5].

The conventional visual analysis is based only on the image behavior of the lesion, leaving gaps in the diagnosis. Therefore, radiomics could be recommended as an auxiliary tool in the elaboration of the radiologists' report, since the analysis is independent of subjective evaluations[29,35]. Thus, the use of texture analyses in imaging is a striking option, potentially allowing the development of a novel form of disease biomarkers, when integrated to clinical and genomic patient data from multiple sources. The texture analysis has the potential to enhance diagnosis accuracy and delivery personalized healthcare, preventing the need for more invasive steps, such as biopsy or surgery[1,42,44–46].

To gain the trust of health professionals, recognized institutions, and patients, an imaging diagnostic system must be transparent, interpretable, and explainable[47]. Significant progress has been made, but further improvements are imperative to achieve routine utilization of radiomics due to the insufficient evidence. There are notable differences in terms of sample size, methodology, performance metrics, and clinical utility[7,48]. Important efforts have been made to address these issues, including the cooperation of different institutions such as the American College of Radiology Imaging Network and the Canadian Institute of Health Research[48]. Working groups that include radiologists, physicists, applied mathematicians and computer scientists aim to improve the field and educate people on radiomics use as a reliable part of a decision-support system in clinical assistance[1,48]. Another milestone in radiomics is the creation of a predictive tool model. It requires the involvement of different imaging centers from all over the world to provide data and a worldwide standardization of the radiomics process[49]. Although there are many challenges to overcome, the potential benefits to precision health care are enormous and may revolutionize radiology practice in the near future.

Limitations

In this review, neither the size of the ROI/ VOI nor the 3D vs 2D images influences were evaluated. In addition, the imaging pre- and post- processing techniques were not deeply explored, and the segmentation phase, which is a crucial radiomics step, was not critically assessed. As a great variety of statistical approaches and different overlapping reduction methods were used, a carefully work focused on this subject is strongly suggested. Although the included studies reported jawbone alterations, few of them were published in dentistry journals, which shows that there is still a lack of dentists' engagement in this area of study.

CONCLUSION

Feature extraction and analysis is just one part of the growing field of radiomics. GLCM feature was the most frequent statistical feature, followed by first-order statistics, and GLRLM features. Shaped-based features were also recurrently mined. No study reported predicting response, prognosis or therapeutic response, but instead disease diagnosis or classification. Due to the lack of standardization showed in this review, there are multiple software and statistical approaches, with the purpose of mining texture parameters, selecting their useful meaning, and building the machine learning models, so that comparison between studies and reproduction of the results is challenging. Aiming to uniform the reports, following the RQS requirements is strongly suggested. Although the limitations of this review, texture analysis showed potential to contribute to radiologists' reports, decreasing the subjectivity when using mathematical approaches, and providing unique, objective and reliable disease information. Therefore, radiomics analysis is a potential quantitative, non-invasive and inexpensive tool for personalized health care.

Protocol and Registration

This systematic review was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Checklist[50]. The protocol was registered in PROSPERO database (University of York) (http://www.crd.york.ac.uk/PROSPERO)[51] under number CRD42022312507.

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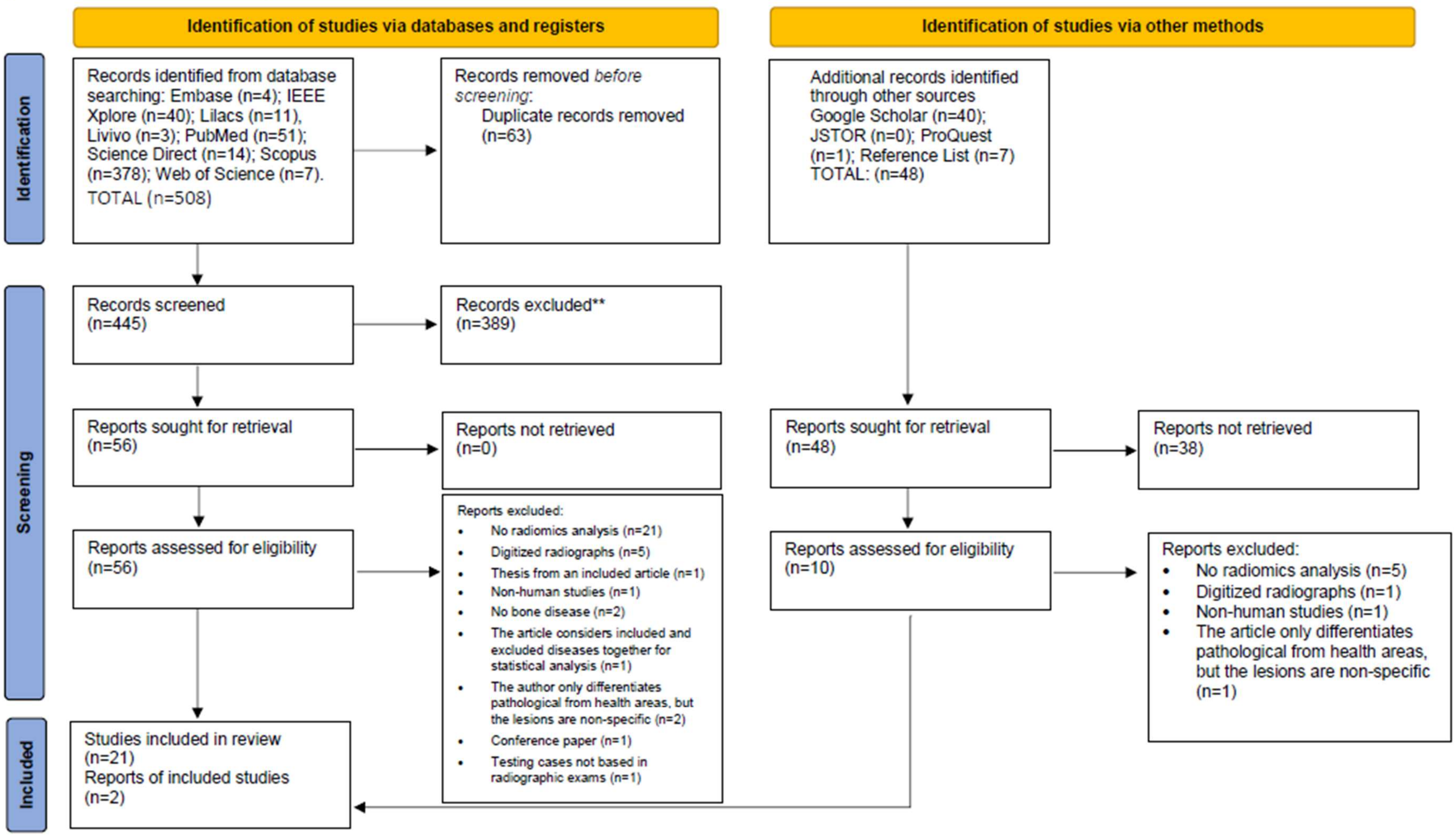
Figure 1 - PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



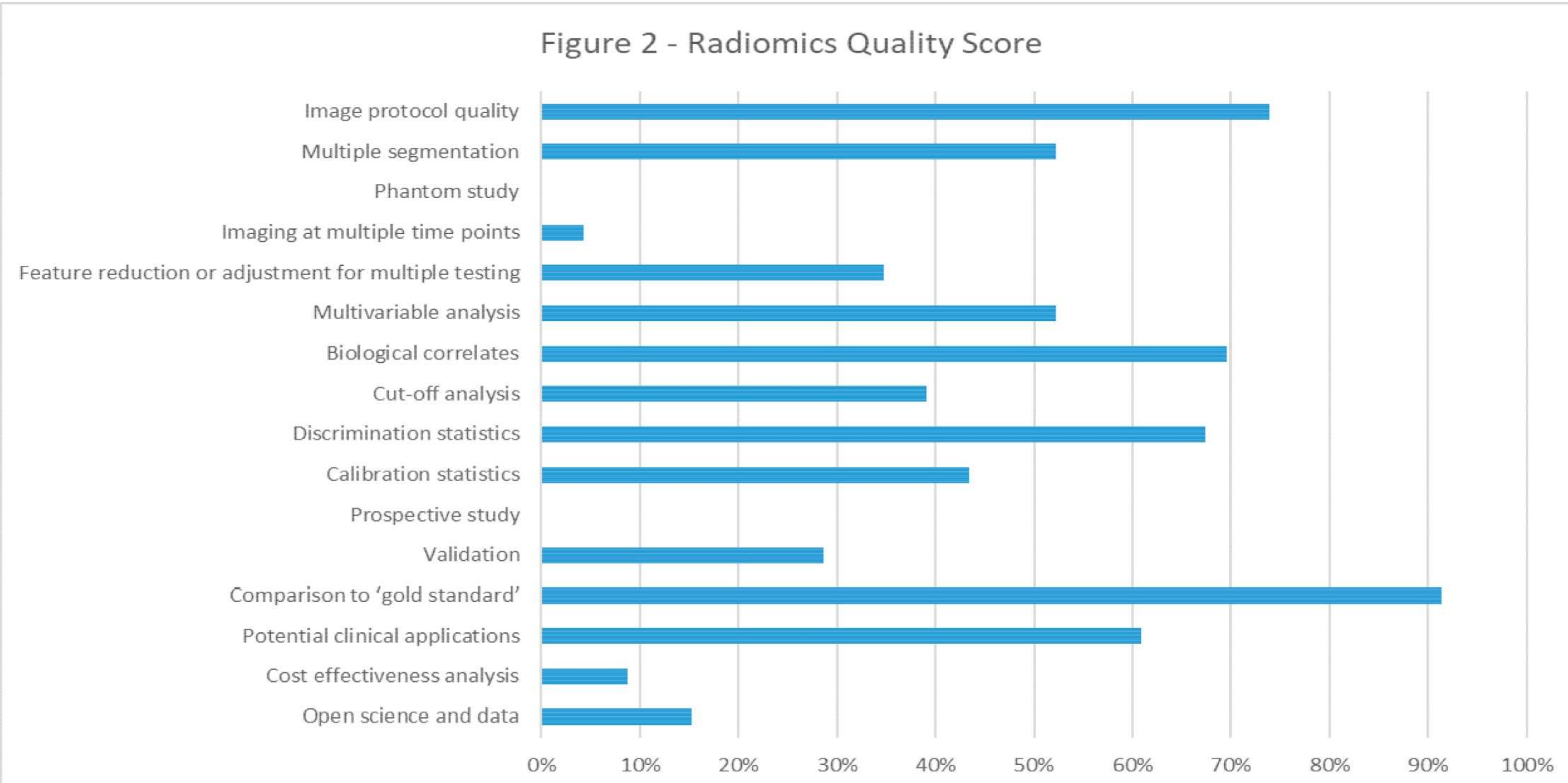


Figure 2 - Radiomics Quality Score
Image protocol quality
Multiple segmentation
Phantom study
Imaging at multiple time points
Feature reduction or adjustment for multiple testing
Multivariable analysis
Biological correlates
Cut-off analysis
Discrimination statistics
Calibration statistics
Prospective study
Validation
Comparison to 'gold standard'
Potential clinical applications
Cost effectiveness analysis
Open science and data
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

Table 1 - Description of the studies' characteristics

Author,year, local	Reference Exam	Objective	Imaging modality	n	Main conclusions
Abdolali et al., 2016 Iran	Histology	Radicular cyst, dentigerous cyst and keratocyst classification	CBCT	125	Using orthogonalized SPHARM (a combination of contourlet and SPHARM features) leads to better results for discriminating between three groups of diseases. SDA performance is superior to SVM in terms of classification accuracy
Alzubaidi & Otoom, 2020 Jordan	DEXA	Osteoporosis classification	DPR	575	The proposed SOM/LVQ method outperformed the SVM method across the 13 feature extractors in terms of the accuracy, sensitivity and specificity performance measures.
Bianchi et al., 2020 (1), USA	Clinical parameters following the DC/TMD for TMJ	TMJ Osteoarthritis diagnosis	CBCT: 3D Accuitomo (J. Morita MFG. CORP Tokyo, Japan), FOV 40x40mm; 90kVp, 5mAs, scanning time of 30.8s and 0.08mm^3 voxel size	92	Entropy, Energy, HarCor features were most accurate to differentiate between control and TMJ Osteoarthritis patients. A decreased value of Energy and increased values for HarCor and Entropy were associated with bone sclerosis/ loss.
Bianchi et al., 2020 (2), USA	Clinical parameters following the DC/TMD for TMJ	TMJ Osteoarthritis diagnosis	CBCT: 3D Accuitomo scanner (J. Morita Mfg. Corp., Tokyo, Japan). FOV of 40x40 mm, 90 kVp, 5 mAs, scanning time of 30.8 s, and 0.08 mm^3 voxel size	84	13 bone imaging biomarkers presented acceptable diagnostic performance for the diagnosis of TMJ Osteoarthritis, indicating that the texture and geometry of the subchondral bone microarchitecture may be useful for quantitative grading of the disease.
De Rosa et al., 2020 Brazil	Histology	Periapical granuloma and radicular cyst classification	CBCT: Promax 3D scanner (Planmeca Oy, Helsinki, Finland), 96kVp, 12mA, FOV of 6cm, voxel size of 200μm and acquisition time of 12s	19	Texture analysis showed potential for differentiating between radicular cysts and periapical granulomas as there was an association between the 5 texture parameters in the characterization of the lesions.
Gonçalves et al., 2020 Brazil	Oral Radiologist diagnosis	Grade C periodontitis diagnosis	CBCT: i-CAT 3D Imaging System (Imaging Sciences International, Hatfield, PA, USA), 37.07 mA, 120 kVp, voxel size of 0.20 mm, exposure time of 26.9 s and FOV of 8.0 x 8.0 mm	34	There were significant statistical differences regarding the textural parameters between groups. This may bring valuable meaning to the

					identification of regions already affected by inflammatory processes that could be unnoticed.
Haghnegahdar et al., 2016 Iran	-	TMJ disorders diagnosis	CBCT	264	k-NN classifier achieved a very good accuracy and showed desirable sensitivity and specificity results. The proposed method could help automatically diagnose TMJ disorders at their initial stages.
Hwang et al., 2017 Korea	DEXA	Osteoporosis diagnosis	DPR: Cranex 3+ Ceph panoramic apparatus (Soredex Co, Helsinki, Finland), 67–71 kV at 10 mA (exposure time, 19.5 s). Images were read using a FCR XG5000 cassette reader (Fuji film Co, Tokyo, Japan) at 170 dpi	454	Endosteal margin area was an effective ROI that showed statistically significant differences in FD, GLCM and strut variables between osteoporotic and non-osteoporotic patients, whereas the medullary portions of DPR showed few distinguishing features. It was also found that the strut variables showed the highest sensitivity, specificity and accuracy using the decision tree and SVM.
Ito et al., 2021 (1), Japan	MRI alterations + no CT and no clinical alterations	MRONJ diagnosis	CT: 64-multi-detector row CT scanner (Aquilion 64; Toshiba Medical Systems, Tokyo, Japan) using the craniomaxillofacial protocol; tube voltage, 120 kV; tube current, 100 mA; FOV 240 × 240 mm; and helical pitch, 41. The protocol consisted of axial (0.50 mm) and multiplanar (3.00 mm) images	25	CT was able to quantitatively assess texture features of normal mandibular bone marrow and that with MRONJ. Texture analysis may be useful as a new method for detecting stage 0 MRONJ using CT.
Ito et al., 2021 (2), Japan	Blood examination	Diabetes mellitus type 2 diagnosis	CT: 64-multi-detector row CT system (Aquilion 64; Toshiba Medical Systems, Tokyo, Japan). Protocol for craniomaxillofacial: tube voltage, 120 kV; tube current, 100 mA; FOV 240×240 mm; and helical pitch, 41. The imaging included axial (0.50 mm) and multiplanar (3.00 mm) images.	32	The value of entropy and difference entropy were significantly higher in diabetes mellitus patients than in non- diabetes mellitus patients. From the histogram, GLCM, and GLRLM results, mandibular condylar bone marrow of diabetes mellitus patients was overall non-uniform, but uniform locally, and had high brightness values. These results suggested the presence of osteosclerosis in the mandibular condyle of these patients. There was a correlation between all texture parameters and HbA1c. From this result, it is considered that the changes in the mandibular condyle bone marrow become more prominent in severe diabetes mellitus patients. CT texture analysis may have the potential to detect diabetes from the mandibular condyle bone marrow.

Jiang et al., 2021, China	Surgical exploration	Jaw simple bone cyst diagnosis	CBCT: DCTPRO, VATECH (Yongin-Si, Republic of Korea); FOV of 16 × 7 cm and a voxel size of 0.16 mm; 90.0 kV and 9 mA and 24 s scanning time	38	GLCM contrast, NGTDM contrast, and GLCM variance may be the characteristic imaging features of simple bone cysts of the jaw. The two non-texture features (volume and size) were significantly different between the groups.
Kavitha et al., 2014 Korea	DEXA	Osteoporosis diagnostic and classification	DPR: OP-100D, Imaging Instrumentarium, Tusuula, Finland	141	The combination of textural features (FD and GLCM) and MCW using three classifiers showed better discriminatory values to identify osteoporosis or low BMD than using only MCW. The overall accuracy of the classification for all feature sets using the SVM classifier was slightly higher than those using the naïve Bayes or k-NN classifiers.
Kawashima et al., 2019 USA	DEXA	Osteoporosis diagnosis	CT Noncontrast head scans axially acquired on 64-detector row CT scanners (Lightspeed VCT; GE Healthcare, Milwaukee, Wisconsin, USA), 120 kV, 225 mA, 1 s/rotation	58	Results demonstrated the ability of a texture analysis to distinguish between osteoporosis and normal bone mineral density, despite potential osteoarthritic changes.
Marar et al., 2020 Jordan	DEXA	Osteoporosis diagnosis	CBCT: CS8100 3D machine, 75kvp and 4mAs (Carestream Dental LLC, Atlanta, GA, USA)	120	Applying the ANN to distinguish between healthy and osteoporotic persons resulted to almost 98% successful classification rate of the testing set. With the help of the proposed scheme, dentists could be able to predict osteoporosis accurately and efficiently.
Muraoka et al., 2022 Japan	Clinical symptoms and image findings	Acute osteomyelitis diagnosis	MRI: 1.5 T superconducting unit (InteraAchieva® 1.5T Nova; Philips Medical Systems, Best, Netherlands) and a 5-channel phased array coil. The STIR images were obtained using a spin echo sequence with the following parameters: TR/TE/ TI = 2500/60/180 ms; other conditions were: 6.0mm section thickness, 320 × 256 matrix, 230 × 195.5mm FOV	38	The histogram and texture features of the bone marrow in the mandible were significantly different in those with acute osteomyelitis than in those without it. The 90th percentile was higher in patients with acute osteomyelitis, suggesting that they exhibit regions with higher brightness values in the bone marrow. The sum averages were higher in acute osteomyelitis patients, suggesting that they have a region with a heterogeneity of tissue density in the bone marrow. Heterogeneity is higher in the bone marrow of acute osteomyelitis group than in that of the control group.
Nurtanio et al., 2013, Indonesia	-	Cyst and Tumor Lesions classification	DPR: Cranex 2.5+ Soredex dental panoramic x-Ray Machine model PT-12SA, Tusuula, Finland	133	The highest performance achieved as the result of the combination of FO and GLRLM. GLCM did not achieve good accuracy.

Oda et al., 2019 USA	Histology	Dentigerous cyst, keratocyst and ameloblastoma classification	CT: Non-contrast 64- detector row CT scanner (Lightspeed VCT; GE Healthcare, Milwaukee, Wisconsin, USA) with 120 kV, 225 mA and 1 s/rotation, and 1.25 mm thick images were reconstructed using soft tissue and bone algorithms. Axial 1.25 mm images in soft tissue algorithm reconstruction were used	98	GLCM, GLRL, GLGM, Laws features and Chi-square features showed significant differences when comparing dentigerous cysts and odontogenic keratocysts. Dentigerous cysts contain fluid with or without inflammatory cells, cholesterol or hyaline bodies, and may not have a great impact on CT texture features. Odontogenic keratocysts are comprised of keratin debris and fluid which may correspond to a highly complicated pattern of design on CT. Differences between histogram features reflected the high-density component in odontogenic keratocysts.
Okada et al., 2015 USA	Endodontic diagnosis and histology	Periapical cysts and granulomas classification	CBCT: NewTom 3G scanner, QR Srl, Verona, Italy. 360 images at 1◦ intervals in 36 s, with reconstructed image resolution of 512×512 pixels and 12 bits per pixel (4096 grayscale). The pixel size was 0.25×0.25 mm. The axial slice thickness was 0.2 mm	45	Experimental results of the authors showed that CBCT diagnosis can be as accurate as histopathology for differentiating the periapical lesions.
Orhan et al., 2021 Belgium	Clinical parameters following the DC/TMD for TMJ	TMJ pathologies classification	MRI: 1.5 T imaging unit (Signa Horizon, GE Electric, Milwaukee, USA; Gyroscan Intera, Philips Medical Systems, Washington; Magnetom SP 4000, Siemens, Erlangen, Germany) with the help of dual-surface coils (3-inch and 6x8cm surface coils). Acquisitions of axial, sagittal, and coronal planes using fast spin-echo sequences. The images were taken in the closed, partially opened, and maximally opened mouth positions to detect disc displacements.	214	For disc displacement, the RF classifier was the best method in the validation set on diagnostic performance by four indicators. k-NN and RF were found to be the best methods for identifying the mandibular condyle changes, whereas the RF classifier was the best machine learning approach for quantifying TMJ disc placements on MRI.
Pociask et al., 2021 Poland	Histology	Periapical cysts and granulomas classification	Periapical Radiographs: Gendex Kavo 765 DC Intraoral X-Ray System, Biberach, Deutschland; 65kV and 7mA; exposure time of 0.1s and recorded on phosphor plates with a secondary readout of five detectors (CS 7600, Carestream Dentak LLC, Atlanta, GA, USA) connected to a Kamsoft computer system. Resolution from 490x649 to 1528x2024 pixels	62	The differentiation between periapical cysts and granulomas was possible, but a definite distinction was not feasible. The most important information about the differentiation of lesions was found in the border of the lesion. Granulomas create a fibrous capsule, while radicular cysts are lined with epithelium. This feature influences textural analysis of the given lesions. High cross-correlation within the group of texture features obtained from the run length matrix, indicating that the structure was isotropic.

Roberts et al., 2013 United Kingdom	DEXA	Osteoporosis diagnosis	DPR: Planmeca PM2002CC (Planmeca Oy, Helsinki, Finland), Cranex 3DC (Soredex, Tuusula, Finland) 70 kV (constant potential) at 8 mA for 15 s. In Leuven, ADC Solo (Afga, Mortsel, Belgium) was used as the photostimulable phosphor plate system, but other centers used analog images.	663	Texture classifiers based on co-occurrence statistics perform much better than those based on FD that have been investigated previously. The combined classifier using cortical texture and width results showed a significantly stronger association with osteoporosis at the femoral neck than width-only methods, but at other skeletal sites there is little if any improvement.
Sela & Widyaningrum, 2015 Indonesia	DEXA	Osteoporosis diagnosis	DPR: Panoura deluxe dental X-ray unit with 70-80 kVp, 12mA, and 12 s exposure (Yoshida Dental Mfg. Co., Ltd., Japan). Periapical radiograph: DBSWin 4.5, Durr Dental (Bietigheim-Bissingen, Deutschland)	69	The proposed model could perform for osteoporosis detection using the selected porous trabecular bone features.
Yilmaz et al., 2017 Turkey	Clinical, radiographic, and histopathologic features	Periapical cyst and keratocyst classification	CBCT: KODAK K9500 Trophy device (Carestream Health, Rochester, NY, USA)	50	The use of features extracted from datasets for classification of dental lesions as periapical cysts or keratocystic odontogenic tumor was determined to be appropriate. The best performance results were achieved using the SVM classifier.

CBCT= Cone-beam computed tomography; SPHARM= Spherical Harmonics; SDA= sparse discriminant analysis, SVM= support vector machine; SOM-LVQ= Self-Organizing Map - Learning vector quantization; DC/TMD= Diagnostic Criteria for Temporomandibular Disorders; TMJ= Temporomandibular Joints; FOV= Field of View; HarCor= Haralick Correlation; CT= Computed Tomography; k-NN= k-Nearest Neighbors; DEXA= dual-energy X-ray absorptiometry; DPR= Dental Panoramic Radiograph; ROI= Region of Interest; FD= fractal dimension; GLCM= Gray-Level Co-occurrence Matrix; MRI= Magnetic Resonance Imaging; MRONJ= medication-related osteonecrosis of the jaw; NGTDM= Neighboring Gray Tone Difference Matrix; MCW= mandibular cortical width; BMD= Bone mineral density; ANN= Artificial Neural Networks; MCD= mandibular cortical degree; MRI= Magnetic Resonance Imaging; FO= first-order statistics texture; GLRLM= Gray Level Run Length Matrix; GLRL= gray-level run-length; RF= Random Forest.

Table 2 – Radiomics workflow

Osteoporosis								
Author, year	Software	Imaging processing	Segmentation	Features extracted	Classifier	Validation	Results	RQS
Alzubaidi et al., 2020	-	Histogram Equalization	Manual	Agnostic features: shaped-based, first-order and filtering	Supervised learning: SOM/LQV	Internal	Gabor-based algorithm achieved an accuracy of 92.6%, a sensitivity of 97.1%, and a specificity of 86.4% in SOM/LVQ classification method	13
Hwang et al., 2017	In house developed software (MATLAB and ImageJ)	Black and white normalization; Upsampling; Gaussian blur; Density correction; Binarization; Skeletonization	Manual	Agnostic features: shaped-based and GLCM	Supervised learning: Decision tree and SVM	Internal	Strut variables in the endosteal margin area were sensitivity, specificity, and accuracy of the 97.1%, 95.7 and 96.25 using the decision tree and 97.2%, 97.1 and 96.9% using SVM	12
Kavitha et al., 2014	In house developed software	Histogram equalization; Clustering thresholding; High-pass filtering	Manual	Agnostic features: shaped-based and GLCM	Supervised learning: Naïve Bayes, k-NN and SVM	Internal	The combinations of FD plus MCW (95.3%, 92.1%, 96.8%) and GLCM plus MCW (93.7%, 89.5%, 94.2%) for femoral neck BMD showed the highest diagnostic accuracy using the naïve Bayes, k-NN and SVM classifiers, respectively.	9
Kawashima et al., 2019	In house developed software	Kernels reconstructions	Manual	Agnostic features: first-order, GLCM, GLRLM, GLGM, Law features	-	-	22 features including 6 histogram, 3 GLCM, 9 GLRLM, 2 GLGM and 2 Law's features demonstrated a statistically significant difference in both sides of the condyle.	8
Marar et al., 2020	MATLAB	Gray Scale Image Conversion; Illumination filtering based on Retinex method; Canny edge detection; Otsu segmentation	Semi-automatic	Agnostic features: shaped-based and Tamura texture features for 3D images	Supervised learning: BPANN	Internal	The performance of the suggested feed forward BPANN classifier was measured by precision, recall, and accuracy which were 0.96, 1, and 97.917%, respectively.	7
Roberts et al., 2013	-	Square-rooted German-McClure kernel function normalization	Automatic	Agnostic features: Shaped-based and GLCM	Supervised learning: Random Forest Classifier	External	AUC values for identifying osteoporosis at femoral neck were 0.830, 0.824, and 0.872 using, respectively, cortical width alone, cortical texture (GLCM) alone and combined width with texture. At 80% sensitivity, these classifiers produced specificity values of 74.4%, 73.6%, and 80.0%, respectively.	22

Sela et al., 2015	Custom computer program	Tophat and bothat filtering and histogram equalization	Automatic	Agnostic features: Shaped-based analysis (porosity)	Supervised learning: Decision tree	Internal	From 54 training data, 49 data can be detected correctly. The results of performance detection obtained accuracy, sensitivity, specificity were 73.33%, 72.23%, and 72.23%, respectively.	14
TMJ Pathology								
Bianchi et al., 2020 (1)	'BoneTexture' module in 3D Slicer; Ibex; ITK-Snap	Optimization using i-Dixel (J. Morita MFG. CORP Tokyo, Japan) filter: G_103+H_009	Manual	Semantic features: biomolecular (saliva and blood), and clinical variables Agnostic features: GLCM, GLRLM and shaped-based (bone morphometry)	Supervised learning: Logistic Regression, Random Forest, LightGBM and XGBoost	Internal	XG-Boost+LightGBM with the interaction features (radiomics, clinical and protein information) achieved the best average accuracy of 0.823, AUC 0,870, and F1-score 0,823 to determine disease status.	22
Bianchi et al., 2020 (2)	'BoneTexture' module in 3D Slicer; ITK-Snap	Mirroring to the right side and creation of a spatial orientation matrix	Manual	Agnostic features: Shaped-based (bone morphometry); GLCM, GLRLM	-	-	Osteoarthritis with AUC values were between 0.620 and 0.710. Good diagnostic performance, especially for energy and entropy, with AUC of ≥ 0.70	12
Haghnegahdar et al., 2016	-	Gray level and LBP	not mentioned	Agnostic feature: first-order	Supervised learning: k-NN, SVM, Naïve Bayes and Random Forest Classifier	Internal	k-NN was the best classifier, by 92.42% accuracy, 94.70% sensitivity and 90.15% specificity.	12
Orhan et al., 2021	Huiying Radiomic platform and Radcloud platform	-	Manual	Agnostic features: shaped-based, first-order, GLCM, GLRLM and GLSZM analysis	Unsupervised and supervised learning: k-means clustering learning; Logistic regression, random forest, decision tree, k-NN, XGBoost and SVM	Internal	AUC of k-NN and random forest were high, with a range of 0.89 and 0.77 for the training set and validation set, respectively.	17
Odontogenic and non- odontogenic cysts and tumors								
Abdolali et al., 2016	MATLAB	Active contour method based on symmetry analysis	Automatic	Agnostic features: shaped-based and contourlet alone, contourlet + conventional SPHARM, and	Supervised learning: SVM, SDA	Internal	A combination of contourlet and SPHARM features leads to better results. The classification accuracy of 94.29% and 96.48% is achieved using SVM and SDA classifier	16

				contourlet + orthogonalized SPHARM analysis				
Jiang et al., 2021	ITK-Snap	Active contour methods	Manual	Semantic features: volume, size, solidity, eccentricity Agnostic features: first-order, GLCM, GLRLM, GLSZM, and NGTDM	-	-	The absolute value of correlation coefficient was 0.487–0.775. GLCM contrast, NGTDM contrast, and GLCM variance were the features with the highest correlation coefficients.	10
Nurtanio et al. 2013	MATLAB	Black and white normalization; Gaussian filter	Manual	Agnostic features: first-order, GLCM, and GLRLM	Supervised learning: SVM	Internal	It was obtained up to 84.62% accuracy using first-order statistical features, 87.18% using the combination of first-order statistical features and GLRLM, and 87.18% using the combination of first-order statistical features, GLCM and GLRLM.	12
Oda et al., 2019	OsiriX (Pixmeo SARL, Bernex, Switzerland) and in-house-developed MATLAB	-	Manual	Semantic features: region, tooth within the lesion, volume, septum Agnostic features: first-order, GLCM, GLRLM, GLGM, Laws features and Chi-square features	-	-	Kruskal-Wallis analysis: 9 histogram features, 1 GLCM feature, 3 GLRLM features, 4 GLGM features, 2 Laws features, and 2 Chi-square features showed significant differences among the different types of lesions. Mann-Whitney's U test analysis: 9 histogram features, 1 GLCM feature, 3 GLRLM features, 4 GLGM features, 2 Laws features, and 2 Chi-square features showed significant differences between DC and OKC; 4 histogram features and 1 Chi-square feature showed significant differences between OKC and AM. 2 histogram features showed significant differences between DC and AM.	10
Yilmaz et al., 2017	In-house-developed MATLAB and Rapid Miner data mining software	-	Manual	Agnostic features: first-order and GLCM	Supervised learning: k-NN, Naïve Bayes, decision trees, random forest, neural network, and SVM	Internal	SVM achieved the best performance with the vector consisting of the single selected feature obtained from 3D GLCM, with a sub-feature vector consisting of two values obtained from 3D GLCM, and with a sub-feature vector consisting of single value obtained from 3D GLCM, respectively. The SVM classifier achieved the best performance of 100% accuracy after feature reduction.	15
Odontogenic Cysts and Granulomas								

De Rosa et al. (2020)	Mazda	Images were converted into bitmap format with loss resolution.	Manual	Semantic features: age, gender, lesion diameter and volume, tooth Agnostic feature:GLCM	-	-	The 5 parameters (angular second moment, sum of squares, sum of average and contrast, with correlations in all directions) were selected for ROC curve as they achieved the AUC of 81.2% in the other half validation set.	7
Okada et al. 2015	MATLAB	Binarization	Semi-automatic	Agnostic feature: first-order	Supervised learning: LDA-AdaBoost method	External	Accuracy of LDA-AdaBoost method using median and minimum intensity was 94.1% for endodontic diagnosis and 78.9% for histopathology as gold standard.	11
Pociask et al. 2021	MaZda	Images were converted into JPG format, with loss resolution and without scale preservation.	Manual	Agnostic features: First-order (histogram-based method), second -order analysis (14 Haralick features), GRLM, GTDM and LBP	Unsupervised and supervised learning: Logistic regression; 2D and 3D t-SNE models	Internal	5 parameters (angular second moment, sum of squares, sum of average and contrast) were selected given their potential to differentiate periapical cysts from granulomas as they achieved the AUC of 81.2%. The best predictor variable was YS6GlcmZ4Entropy texture in logistic regression method.	15
Bone inflammation/ infection								
Gonçalves et al., 2020	MaZda	Images were converted into bitmap format with loss resolution	Manual	Agnostic feature: GLCM	-	-	Comparisons between groups showed statistically significant differences for all parameters. In the inter-group analysis, there were statistically significant differences in inverse difference moment, angular second moment, entropy, sum of average, sum of variance, sum of entropy, difference of variance and difference of entropy parameters.	8
Ito et al., 2021 (1)	Open-access LIFEx software	-	Manual	Semantic features: age, sex, MRONJ stage, bisphosphonates, medical history Agnostic features: GLRLM and GLZLM	-	-	Among 37 texture features, the bone marrow of the mandible with stage 0 MRONJ and the contralateral normal mandibular bone marrow revealed significant differences in 6 GLRLM features and 4 GLZLM features	7
Muraoka et al., 2022	MaZda	Intensity normalization using MaZda default	Manual	Agnostic features: first-order, GLCM, GLRLM	-	-	These radiomics features in the acute osteomyelitis group were significantly higher than in the non-osteomyelitis group ($p < 0.001$)	9
Diabetes Mellitus								
Ito et al., 2021 (2)	MaZda	Intensity normalization using MaZda default	Manual	Agnostic features: first-order, GLRLM, GLCM and wavelets	-	-	One histogram feature, 15 GLCM features, and 4 GLRLM features showed significant differences between the diabetes and control patients cohort	10

RQS= Radiomics Quality Score; SOM= Self-Organizing Map; LVQ= Learning Vector Quantization; GLCM= Gray-Level Co-occurrence Matrix; SVM= Support Vector Machine; k-NN= k-Nearest Neighbors; FD= Fractal Dimension; MCW= Mandibular cortical width; BMD= Bone mineral density; GLRLM= gray-level run-length matrix; GLGM= gray-level gradient matrix; BPANN= Back Propagation Artificial Neural Networks; AUC= Area Under the Curve; LightGBM: Light Gradient Boosting Machine; XGBoost: Extreme Gradient Boosting; LBP= Local binary patterns; GLSZM= Gray Level Size Zone; SPHARM= Spherical Harmonics; SDA= sparse discriminant analysis; NGTDM= Neighborhood Gray Tone Difference Matrix; DC= Dentigerous Cyst; AM= Ameloblastoma; OKC= odontogenic keratocysts; LDA= linear discriminant analysis; GTDM= Game Theory Based Decision Making; t-SNE= t-Distributed Stochastic Neighbor Embedding; MRONJ= medication-related osteonecrosis of the jaw; GLZLM= gray-level zone length matrix;

Supplementary Material 1. Database Search

Database	Search
Embase (Jan 12, 2022)	(('dental radiography':ti,ab,kw OR 'facial scanning':ti,ab,kw OR 'intraoral radiography':ti,ab,kw OR 'intra-oral radiography':ti,ab,kw OR 'intra oral radiography':ti,ab,kw OR 'intraoral imaging':ti,ab,kw OR 'intra-oral imaging':ti,ab,kw OR 'intra oral imaging':ti,ab,kw OR 'intraoral scanning':ti,ab,kw OR 'periapical radiography':ti,ab,kw OR 'periapical imaging':ti,ab,kw OR 'extraoral radiography':ti,ab,kw OR 'extra-oral radiography':ti,ab,kw OR 'extra oral radiography':ti,ab,kw OR 'extraoral imaging':ti,ab,kw OR 'extra-oral imaging':ti,ab,kw OR 'extra oral imaging':ti,ab,kw OR 'bitewing radiography':ti,ab,kw OR 'bitewing radiographies':ti,ab,kw OR 'dental digital radiography':ti,ab,kw OR 'dental panoramic radiographs':ti,ab,kw OR 'dental panoramic radiograph':ti,ab,kw OR 'pantomography':ti,ab,kw OR 'pantomographies':ti,ab,kw OR 'orthopantomography':ti,ab,kw OR 'orthopantomographies':ti,ab,kw OR 'panoramic radiography':ti,ab,kw OR 'panoramic radiographies':ti,ab,kw 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related osteonecrosis of the

	jaw':ti,ab,kw OR 'bisphosphonate-associated osteonecrosis of the jaws':ti,ab,kw OR 'bisphosphonate associated osteonecrosis of the jaws':ti,ab,kw OR 'bisphosphonate-associated osteonecrosis':ti,ab,kw OR 'bisphosphonate associated osteonecrosis':ti,ab,kw OR 'bisphosphonate-associated osteonecroses':ti,ab,kw OR 'bisphosphonate osteonecrosis':ti,ab,kw OR 'bisphosphonate osteonecroses':ti,ab,kw OR 'osteosarcomas':ti,ab,kw OR 'osteosarcoma tumor':ti,ab,kw OR 'osteosarcoma tumors':ti,ab,kw OR 'osteogenic sarcomas':ti,ab,kw OR 'osteogenic sarcoma':ti,ab,kw OR 'ewing sarcoma':ti,ab,kw OR 'sarcoma ewing':ti,ab,kw OR 'osteoblastomas':ti,ab,kw OR 'giant osteoid osteoma':ti,ab,kw OR 'giant osteoid osteomas':ti,ab,kw OR 'osteoid osteomas':ti,ab,kw OR 'osteoid osteoma':ti,ab,kw OR 'osteochondromas':ti,ab,kw OR 'osteocartilaginous exostoses':ti,ab,kw OR 'osteocartilaginous exostosis':ti,ab,kw OR 'chondrosteoma':ti,ab,kw OR 'chondrosteomas':ti,ab,kw OR 'giant cell tumor of bone':ti,ab,kw OR 'bone fibrous dysplasia':ti,ab,kw OR 'bone fibrous dysplasias':ti,ab,kw OR 'fibrocystic dysplasia of bone':ti,ab,kw OR 'bone fibrocystic dysplasia':ti,ab,kw OR 'bone fibrocystic dysplasias':ti,ab,kw OR 'fibrocartilaginous dysplasia of bone':ti,ab,kw OR 'bone fibrocartilaginous dysplasia':ti,ab,kw OR 'bone fibrocartilaginous dysplasias':ti,ab,kw OR 'bone dysplasias':ti,ab,kw OR 'bone dysplasia':ti,ab,kw OR 'ossifying fibroma':ti,ab,kw OR 'ossifying fibromas':ti,ab,kw OR 'furcal lesion':ti,ab,kw OR 'furcal lesions':ti,ab,kw OR 'periodontal disease':ti,ab,kw OR 'periodontal diesases':ti,ab,kw OR 'periodontitis':ti,ab,kw OR 'aggressive periodontitis':ti,ab,kw OR 'periodontitis grade c':ti,ab,kw OR 'grade c periodontitis':ti,ab,kw OR 'periodontal bone losses':ti,ab,kw OR 'periodontal bone loss':ti,ab,kw OR 'osteoporosis':ti,ab,kw OR 'osteoporoses':ti,ab,kw OR 'post-traumatic osteoporoses':ti,ab,kw OR 'post-traumatic osteoporosis':ti,ab,kw OR 'senile osteoporoses':ti,ab,kw OR 'senile osteoporosis':ti,ab,kw OR 'age-related bone loss':ti,ab,kw OR 'age-related bone losses':ti,ab,kw OR 'age-related osteoporosis':ti,ab,kw OR 'age related osteoporosis':ti,ab,kw OR 'age-related osteoporoses':ti,ab,kw OR 'periapical disease':ti,ab,kw OR 'periapical diseases':ti,ab,kw OR 'furcation defects':ti,ab,kw OR 'furcation defect':ti,ab,kw OR 'alveolar resorption':ti,ab,kw OR 'alveolar resorptions':ti,ab,kw OR 'alveolar bone resorption':ti,ab,kw OR 'alveolar bone resorptions':ti,ab,kw OR 'osteoarthritis':ti,ab,kw OR 'osteoarthritides':ti,ab,kw OR 'osteoarthrosis':ti,ab,kw OR 'osteoarthroses':ti,ab,kw OR 'degenerative arthritides':ti,ab,kw OR 'degenerative arthritis':ti,ab,kw OR 'arthrosis':ti,ab,kw OR 'arthroses':ti,ab,kw OR 'osteoarthrosis deformans':ti,ab,kw) AND jaws:ti,ab,kw OR 'jaw':ti,ab,kw OR 'jawbones':ti,ab,kw OR 'jawbone':ti,ab,kw OR 'mandibles':ti,ab,kw OR 'mandible':ti,ab,kw OR 'mandibular bone':ti,ab,kw OR 'mandibular bones':ti,ab,kw OR 'dentomaxillofacial':ti,ab,kw OR 'dento-maxillo-facial':ti,ab,kw OR 'dento maxillo facial':ti,ab,kw OR 'maxillofacial':ti,ab,kw OR 'maxillo-facial':ti,ab,kw OR 'maxillas':ti,ab,kw OR 'maxilla':ti,ab,kw OR 'mandibular bony structures':ti,ab,kw OR 'mandibular bony structure':ti,ab,kw OR 'maxillary bone':ti,ab,kw OR 'maxillary bones':ti,ab,kw OR 'maxillae':ti,ab,kw OR 'facial bone':ti,ab,kw OR 'facial bones':ti,ab,kw OR 'alveolar bone losses':ti,ab,kw OR 'alveolar bone loss':ti,ab,kw OR 'alveolar bone':ti,ab,kw OR 'alveolar bones':ti,ab,kw OR 'furcal':ti,ab,kw OR 'periapical':ti,ab,kw OR 'periapex':ti,ab,kw) AND ('jaws':ti,ab,kw OR 'jaw':ti,ab,kw OR 'jawbones':ti,ab,kw OR 'jawbone':ti,ab,kw OR 'mandibles':ti,ab,kw OR 'mandible':ti,ab,kw OR 'mandibular bone':ti,ab,kw OR 'mandibular bones':ti,ab,kw OR 'dentomaxillofacial':ti,ab,kw OR 'dento-maxillo-facial':ti,ab,kw OR 'dento maxillo facial':ti,ab,kw OR 'maxillofacial':ti,ab,kw OR 'maxillo-facial':ti,ab,kw OR 'maxillas':ti,ab,kw OR 'maxilla':ti,ab,kw OR 'mandibular bony structures':ti,ab,kw OR 'mandibular bony structure':ti,ab,kw OR 'maxillary bone':ti,ab,kw OR 'maxillary bones':ti,ab,kw OR 'maxillae':ti,ab,kw OR 'facial bone':ti,ab,kw OR 'facial bones':ti,ab,kw OR 'alveolar bone losses':ti,ab,kw OR 'alveolar bone loss':ti,ab,kw OR 'alveolar bone':ti,ab,kw OR 'alveolar bones':ti,ab,kw OR 'furcal':ti,ab,kw OR 'periapical':ti,ab,kw OR 'periapex':ti,ab,kw) AND (('radiomics':ti,ab,kw OR 'radiomics technique':ti,ab,kw OR 'radiomic':ti,ab,kw OR 'texture analysis':ti,ab,kw) AND ta:ti,ab,kw OR 'radiomic machine learning':ti,ab,kw OR 'feature extraction':ti,ab,kw)
IEEE Xplore (Jan 12, 2022)	("All Metadata":"Dental Radiography" OR "All Metadata":"facial scanning" OR "All Metadata":"Intraoral radiography" OR "All Metadata":"Intra-oral radiography" OR "All Metadata":"Intra oral radiography" OR "All Metadata":"Intraoral imaging" OR "All Metadata":"Intra-oral imaging" OR "All Metadata":"Intra oral imaging" OR "All Metadata":"intraoral scanning" OR "All Metadata":"Periapical radiography" OR "All Metadata":"Periapical imaging" OR "All Metadata":"Extraoral radiography" OR "All

	Metadata":"Extra-oral radiography" OR "All Metadata":"Extra oral radiography" OR "All Metadata":"Extraoral imaging" OR "All Metadata":"Extra-oral imaging" OR "All Metadata":"Extra oral imaging" OR "All Metadata":"Bitewing Radiography" OR "All Metadata":"Bitewing Radiographies" OR "All Metadata":"Dental Digital Radiography" OR "All Metadata":"Dental panoramic radiographs" OR "All Metadata":"Dental panoramic radiograph" OR "All Metadata":"Pantomography" OR "All Metadata":"Pantomographies" OR "All Metadata":"Orthopantomography" OR "All Metadata":"Orthopantomographies" OR "All Metadata":"Panoramic Radiography" OR "All Metadata":"Panoramic Radiographies" OR "All Metadata":"Cone Beam Computed Tomography" OR "All Metadata":"Cone-beam computed tomography (CBCT)" OR "All Metadata":CBCT OR "All Metadata":"CBCT scans" OR "All Metadata":"Cone-Beam CT Scan" OR "All Metadata":"Cone-Beam CT Scans" OR "All Metadata":"Volume Computed Tomography" OR "All Metadata":"Volumetric CT" OR "All Metadata":"Volumetric Computed Tomography" OR "All Metadata":"Cone-Beam CAT Scan" OR "All Metadata":"Cone-Beam CAT Scans" OR "All Metadata":"Cone-Beam Computer-Assisted Tomography" OR "All Metadata":"Cone Beam Computer Assisted Tomography" OR "All Metadata":"Cone-Beam Computerized Tomography" OR "All Metadata":"Cone Beam Computerized Tomography" OR "All Metadata":"Cone-Beam CT" OR "All Metadata":"Cone Beam CT" OR "All Metadata":"Volume CT" OR "All Metadata":"NMR Imaging" OR "All Metadata":"MR Tomography" OR "All Metadata":"NMR Tomography" OR "All Metadata":"Steady-State Free Precession MRI" OR "All Metadata":"Steady State Free Precession MRI" OR "All Metadata":"Zeugmatography" OR "All Metadata":"Magnetic Resonance Image" OR "All Metadata":"Magnetic Resonance Images" OR "All Metadata":"Magnetization Transfer Contrast Imaging" OR "All Metadata":"MRI Scans" OR "All Metadata":"MRI Scan" OR "All Metadata":"Proton Spin Tomography" OR "All Metadata":"fMRI" OR "All Metadata":"Functional MRI" OR "All Metadata":"Functional MRIs" OR "All Metadata":"Functional Magnetic Resonance Imaging" OR "All Metadata":"Spin Echo Imaging" OR "All Metadata":"Spin Echo Imagings" OR "All Metadata":"PET-CT Scan" OR "All Metadata":"PET-CT Scans" OR "All Metadata":"PET CT Scan" OR "All Metadata":"PET CT Scans" OR "All Metadata":"CT PET" OR "All Metadata":"Positron Emission Tomography-Computed Tomography" OR "All Metadata":"PET-CT" OR "All Metadata":"CT PET Scan" OR "All Metadata":"CT PET Scans" OR "All Metadata":"Radioisotope Scanning" OR "All Metadata":Scintigraphy OR "All Metadata":"Gamma Camera Imaging" OR "All Metadata":Scintiphotography OR "All Metadata":"SPECT CT" OR "All Metadata":"CT SPECT Scan" OR "All Metadata":"CT SPECT Scans" OR "All Metadata":"CT SPECT" OR "All Metadata":"CT SPECTs" OR "All Metadata":"SPECT CT Scan" OR "All Metadata":"SPECT CT Scans" OR "All Metadata":"Multisection Computed Tomography" OR "All Metadata":"Dual-energy CT" OR "All Metadata":"Multidetector row CT" OR "All Metadata":"Perfusion CT" OR "All Metadata":"Multislice Computed Tomography" OR "All Metadata":"Multidetector-Row Computed Tomography" OR "All Metadata":"Multidetector Row Computed Tomography" OR "All Metadata":"Diagnostic imaging" OR "All Metadata":"Medical Imaging") AND ("All Metadata":"bone") AND ("All Metadata":"Radiomics" OR "All Metadata":"Radiomics technique" OR "All Metadata":"Radiomic" OR "All Metadata":"Texture Analysis" OR "All Metadata":"Texture Analysis (TA)" OR "All Metadata":"Radiomic Machine Learning" OR "All Metadata":"feature extraction")
Lilacs (Jan 12, 2022)	("Radiologia" OR "Radiology" OR "Radiología" OR "Medicina Nuclear" OR "Nuclear Medicine" OR "Medicina Nuclear" OR "Nuclear Radiology" OR "Radiografia" OR "Roentgenografia" OR "Roentgenography" OR "Roentgenografía" OR "Radiografía" OR "Radiografia Dentária" OR "Dental Radiography" OR "Radiografía Dental" OR "Radiografia Interproximal" OR "Bitewing Radiographies" OR "Bitewing Radiography" OR "Radiografía de Mordida Lateral" OR "Radiografia Panorâmica" OR "Ortopantomografia" OR "Pantomografia" OR "Orthopantomographies" OR "Orthopantomography" OR "Panoramic Radiographies" OR "Panoramic Radiography" OR "Pantomographies" OR "Pantomography" OR "Radiografía Panorámica" OR "Ortopantomografía" OR "Pantomografía" OR "Imagem de Ressonância Magnética" OR "Imagem por Ressonância Magnética" OR "Imagem por RMN" OR "Magnetic Resonance Imaging" OR "Magnetic Resonance Image" OR "Magnetic Resonance Images" OR "MRI Scan" OR "MRI Scans" OR "NMR Imaging" OR

"Zeugmatography" OR "Imagen por Resonancia Magnética" OR "Imagen de Resonancia Magnética" OR "Imagen por RMN" OR "Tomografia" OR "Tomografía" OR "Tomography" OR "Tomographies" OR "Tomografia Computadorizada de Emissão de Fóton Único" OR "CT SPECT" OR "CT SPECT Scan" OR "SPECT CT" OR "SPECT CT Scan" OR "CT SPECT" OR "CT SPECT Scan" OR "CT SPECT Scans" OR "CT SPECTs" OR "SPECT CT" OR "SPECT CT Scan" OR "SPECT CT Scans" OR "Tomografía Computarizada de Emisión de Fotón Único" OR "Examen por SPECT-TC" OR "SPECT CT" OR "SPECT-CT" OR "Tomografía Computarizada de Emisión Monofotónica" OR "Tomografia Computadorizada de Feixe Cônico" OR "TC de Feixe Cônico" OR "Cone-Beam Computed Tomography" OR "Cone Beam Computed Tomography" OR "Cone Beam Computerized Tomography" OR "Cone Beam CT" OR "Cone-Beam CT" OR "Tomografía Computarizada de Haz Cónico" OR "TC de Haz Cónico" OR "Tomografia Computadorizada Espiral" OR "TC Espiral" OR "TC Helicoidal" OR "Tomografia Computadorizada Helicoidal" OR "Tomografia Espiral Computadorizada" OR "Helical Computed Tomography" OR "Helical CT" OR "Helical CTs" OR "Spiral Computed Tomography" OR "Spiral Computer-Assisted Tomography" OR "Spiral Computerized Tomography" OR "Spiral CT" OR "Spiral CTs" OR "TC Espiral" OR "TC Helicoidal" OR "Tomografía Computada Helicoidal" OR "Tomografía Computarizada en Espiral" OR "Tomografía Computarizada Helicoidal" OR "Tomografía Espiral Computarizada" OR "Tomografía Helicoidal Computarizada" OR "Tomografía Computarizada Espiral" OR "Tomografia Computadorizada Multidetectores" OR "TCMD" OR "Multidetector Computed Tomography" OR "Multidetector Row Computed Tomography" OR "Multidetector-Row Computed Tomography" OR "Multislice Computed Tomography" OR "Tomografía Computarizada Multidetector" OR "Tomografia por Emissão de Pósitrons" OR "PET Scan" OR "Tomografia de Emissão de Pósitrons" OR "Positron-Emission Tomography" OR "PET Imaging" OR "PET Imagings" OR "PET Scan" OR "PET Scans" OR "Positron Emission Tomography" OR "Positron-Emission Tomography Imaging" OR "Tomografía de Emisión de Positrones" OR "Imágenes PET" OR "Tomografía por Emisión de Positrón" OR "CT-PET" OR "CT-PET Scan" OR "PET CT" OR "PET CT Scan" OR "Tomografia Computadorizada por Emissão de Pósitrons" OR "Positron Emission Tomography Computed Tomography" OR "CT PET" OR "CT PET Scan" OR "CT PET Scans" OR "PET CT Scan" OR "PET CT Scans" OR "PET-CT" OR "PET-CT Scan" OR "PET-CT Scans" OR "Positron Emission Tomography-Computed Tomography" OR "Examen por PET-TC" OR "PET CT" OR "Cintilografia" OR "Imagem de Câmara Gama" OR "Gamma Camera Imaging" OR "Radioisotope Scanning" OR "Scintigraphy" OR "Radionuclide Imaging" OR "Cintigrafía" OR "Escanografía Nuclear" OR "Gammagrafía" OR "Imagen por Cámara Gamma" OR "Imagen por Gammacámara") AND ("Displasia Fibrosa Óssea" OR "Displasia Fibrosa do Osso" OR "Displasias Ósseas Fibrosas" OR "Bone Fibrous Dysplasia" OR "Bone Fibrous Dysplasias" OR "Fibrous Dysplasia of Bone" OR "Displasia Fibrosa Ósea" OR "Displasia Fibrosa del Hueso" OR "Displasias Fibrosas Óseas" OR "Baixa Densidade Mineral Óssea" OR "Baixa Densidade Óssea" OR "Doenças Metabólicas do Osso" OR "Doenças Metabólicas Ósseas" OR "Osteopatias Metabólicas" OR "Osteopenia" OR "Low Bone Densities" OR "Low Bone Density" OR "Low Bone Mineral Density" OR "Metabolic Bone Disease" OR "Metabolic Bone Diseases" OR "Osteopenia" OR "Osteopenias" OR "Enfermedades Óseas Metabólicas" OR "Densidad Mineral Ósea Baja" OR "Enfermedades Metabólicas del Hueso" OR "Osteopatias Metabólicas" OR "Neoplasias Ósseas" OR "Câncer de Osso" OR "Câncer Ósseo" OR "Doenças Periapicais" OR "Periapical Disease" OR "Periapical Diseases" OR "Enfermedades Periapicales" OR "Doenças Periodontais" OR "Doença Periodontal" OR "Paradontose" OR "Parodontose" OR "Periodontal Diseases" OR "Parodontoses" OR "Parodontosis" OR "Periodontal Disease" OR "Enfermedades Periodontales" OR "Paradontosis" OR "Parodontosis" OR "Neoplasias Maxilomandibulares" OR "Câncer de Mandíbula e Maxilar" OR "Câncer Maxilomandibular" OR "Jaw Neoplasms" OR "Cancer of the Jaw" OR "Jaw Cancer" OR "Jaw Cancers" OR "Jaw Neoplasm" OR "Neoplasias Maxilomandibulares" OR "Cáncer de la Arcada Oseodentaria" OR "Cáncer Maxilomandibular" OR "Bone Neoplasms" OR "Bone Cancer" OR "Bone Neoplasm" OR "Cancer of Bone" OR "Cancer of the Bone" OR "Neoplasias Óseas" OR "Cáncer de Hueso" OR "Cáncer Óseo" OR "Osteíte" OR "Inflamação do Osso" OR "Osteitis" OR "Bone Inflammation" OR "Osteítis" OR "Inflamación del Hueso" OR "Osteonecrose" OR "Necrose Asséptica do Osso" OR "Necrose Avascular do Osso" OR "Necrose Óssea" OR "Necrose Óssea Asséptica" OR "Necrose Óssea Avascular" OR "Aseptic Necrosis of Bone" OR "Avascular Necrosis of Bone" OR "Bone Aseptic Necrosis" OR "Bone Avascular Necrosis" OR "Bone Necroses" OR "Bone Necrosis" OR "Osteonecroses" OR

	"Osteonecrosis" OR "Necrosis Ósea" OR "Necrosis Ósea Aséptica" OR "Necrosis Ósea Avascular" OR "Perda do Osso Alveolar" OR "Perda Óssea Periodontal" OR "Reabsorção Alveolar" OR "Reabsorção Periodontal" OR "Alveolar Bone Loss" OR "Alveolar Bone Atrophies" OR "Alveolar Bone Atrophy" OR "Alveolar Bone Losses" OR "Alveolar Process Atrophies" OR "Alveolar Process Atrophy" OR "Alveolar Resorption" OR "Alveolar Resorptions" OR "Periodontal Bone Loss" OR "Periodontal Bone Losses" OR "Periodontal Resorption" OR "Periodontal Resorptions" OR "Pérdida de Hueso Alveolar" OR "Pérdida de Hueso Periodontal" OR "Pérdida Ósea Periodontal" OR "Reabsorción Alveolar" OR "Reabsorción Periodontal" OR "Resorción Alveolar" OR "Resorción Periodontal" OR "Tumor de Células Gigantes do Osso" OR "Giant Cell Tumor of Bone" OR "Tumor Óseo de Células Gigantes" OR "Osteomielite" OR "Osteomyelitis" OR "Osteomielitis" OR "Osteossarcoma" OR "Osteossarcomas" OR "Sarcoma Osteogênico" OR "Osteosarcoma" OR "Osteogenic Sarcoma" OR "Osteosarcomas" OR "Sarcoma Osteogénico" OR "Sarcoma de Ewing" OR "Tumor de Ewing" OR "Ewing Sarcoma" OR "Ewing Tumor" OR "Ewing's Sarcoma" OR "Ewing's Tumor" OR "Ewings Sarcoma" OR "Ewings Tumor" OR "Cisto Radicular" OR "Cisto Periapical" OR "Radicular Cyst" OR "Apical Periodontal Cyst" OR "Apical Periodontal Cysts" OR "Periapical Cyst" OR "Periapical Cysts" OR "Radicular Cysts" OR "Quiste Radicular" OR "Quiste Apical Periodontal" OR "Quiste Periapical" OR "Cistos Odontogênicos" OR "Odontogenic Cysts" OR "Quistes Odontogénicos" OR "Cistos Ósseos" OR "Bone Cysts" OR "Quistes Óseos") AND ("Tecido Periapical" OR "Periodonto Apical" OR "Apical Periodontium" OR "Apical Periodontiums" OR "Periapical Tissues" OR "Periodontium, Apical" OR "Periodontiums, Apical" OR "Tissue, Periapical" OR "Tissues, Periapical" OR "Tejido Periapical" OR "Periodoncio Apical" OR "Mandíbula" OR "Mandible" OR "Mandíbula" OR "Maxilar Inferior" OR "Maxila" OR "Maxilar Superior" OR "Maxilla" OR "Bone, Maxillary" OR "Bones, Maxillary" OR "Maxillae" OR "Maxillary Bone" OR "Maxillary Bones" OR "Maxillas" OR "Maxilar" OR "jaw" OR "jaws" OR "Ossos Faciais" OR "Ossos da Face" OR "Facial Bones" OR "Bone, Facial" OR "Bones, Facial" OR "Facial Bone" OR "Huesos Faciales") AND ("Radiomics" OR "Radiomics technique" OR "Radiomic" OR "Texture Analysis" OR "Texture Analysis (TA)" OR "Radiomic Machine Learning" OR "feature extraction")
Livivo (Jan 12, 2022)	TI=("Dental Radiography" OR "facial scanning" OR "Intraoral radiography" OR "Intra-oral radiography" OR "Intra oral radiography" OR "Intraoral imaging" OR "Intra-oral imaging" OR "Intra oral imaging" OR "intraoral scanning" OR "Periapical radiography" OR "Periapical imaging" OR "Extraoral radiography" OR "Extra-oral radiography" OR "Extra oral radiography" OR "Extraoral imaging" OR "Extra-oral imaging" OR "Extra oral imaging" OR "Bitewing Radiography" OR "Bitewing Radiographies" OR "Dental Digital Radiography" OR "Dental panoramic radiographs" OR "Dental panoramic radiograph" OR "Pantomography" OR "Pantomographies" OR "Orthopantomography" OR "Orthopantomographies" OR "Panoramic Radiography" OR "Panoramic Radiographies" OR "Cone Beam Computed Tomography" OR "Cone-beam computed tomography CBCT" OR CBCT OR "CBCT scans" OR "Cone-Beam CT Scan" OR "Cone-Beam CT Scans" OR "Volume Computed Tomography" OR "Volumetric CT" OR "Volumetric Computed Tomography" OR "Cone-Beam CAT Scan" OR "Cone-Beam CAT Scans" OR "Cone-Beam Computer-Assisted Tomography" OR "Cone Beam Computer Assisted Tomography" OR "Cone-Beam Computerized Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Beam CT" OR "Cone Beam CT" OR "Volume CT" OR "NMR Imaging" OR "MR Tomography" OR "NMR Tomography" OR "Steady-State Free Precession MRI" OR "Steady State Free Precession MRI" OR "Zeugmatography" OR "Magnetic Resonance Image" OR "Magnetic Resonance Images" OR "Magnetization Transfer Contrast Imaging" OR "MRI Scans" OR "MRI Scan" OR "Proton Spin Tomography" OR "fMRI" OR "Functional MRI" OR "Functional MRIs" OR "Functional Magnetic Resonance Imaging" OR "Spin Echo Imaging" OR "Spin Echo Imagings" OR "PET-CT Scan" OR "PET-CT Scans" OR "PET CT Scan" OR "PET CT Scans" OR "CT PET" OR "Positron Emission Tomography-Computed Tomography" OR "PET-CT" OR "CT PET Scan" OR "CT PET Scans" OR "Radioisotope Scanning" OR Scintigraphy OR "Gamma Camera Imaging" OR Scintiphotography OR "SPECT CT" OR "CT SPECT Scan" OR "CT SPECT Scans" OR "CT SPECT" OR "CT SPECTs" OR "SPECT CT Scan" OR "SPECT CT Scans" OR "Multisection Computed Tomography" OR "Dual-energy CT" OR "Multidetector row CT" OR "Perfusion CT" OR "Multislice Computed Tomography" OR "Multidetector-Row Computed Tomography" OR

	"Multidetector Row Computed Tomography" OR "Diagnostic imaging" OR "Medical Imaging") AND TI=("Bone Neoplasm" OR "Bone Cancer" OR "Cancer of the Bone" OR "Cancer of Bone" OR "Bone Lesion" OR "Bone Lesions" OR "osseous pathology" OR "bone pathology" OR "osseous pathologies" OR "bone pathologies" OR "Osseous Lesion" OR "Osseous Lesions" OR "Cyst" OR "cysts" OR "Tumor" OR "Neoplasm" OR "Tumors" OR "Neoplasia" OR "Neoplasias" OR "Cancer" OR "Cancers" OR "Malignant Neoplasm" OR "Malignancy" OR "Malignancies" OR "Malignant Neoplasms" OR "Benign Neoplasms" OR "Benign Neoplasm" OR "fibro-osseous lesions" OR "fibro-osseous lesions" OR "fibroosseous lesions" OR "fibroosseous lesion" OR "Inflammatory lesions" OR "Inflammatory lesion" OR "Giant Cell Tumor of Bone" OR "Familial Fibrous Dysplasia of Jaw" OR "Familial Multilocular Cystic Disease of the Jaws" OR "Familial Benign Giant-Cell Tumor of the Jaw" OR "Osteomyelitis" OR "Osteonecroses" OR "Osteonecrosis" OR "Bone Necrosis" OR "Bone Necroses" OR "Avascular Necrosis of Bone" OR "Bone Avascular Necrosis" OR "Aseptic Necrosis of Bone" OR "Bone Aseptic Necrosis" OR "Bisphosphonate Associated Osteonecrosis of the Jaw" OR "Bisphosphonate-Induced Osteonecrosis of the Jaw" OR "Bisphosphonate Induced Osteonecrosis of the Jaw" OR "Bisphosphonate-Induced Osteonecrosis of the Jaws" OR "Bisphosphonate Induced Osteonecrosis of the Jaws" OR "Bisphosphonate-Related Osteonecrosis of the Jaw" OR "Bisphosphonate Related Osteonecrosis of the Jaw" OR "Bisphosphonate-Associated Osteonecrosis of the Jaws" OR "Bisphosphonate Associated Osteonecrosis of the Jaws" OR "Bisphosphonate-Associated Osteonecrosis" OR "Bisphosphonate Associated Osteonecrosis" OR "Bisphosphonate-Associated Osteonecroses" OR "Bisphosphonate Osteonecrosis" OR "Bisphosphonate Osteonecroses" OR "Osteosarcomas" OR "Osteosarcoma Tumor" OR "Osteosarcoma Tumors" OR "Osteogenic Sarcomas" OR "Osteogenic Sarcoma" OR "Ewing Sarcoma" OR "Sarcoma Ewing" OR "Osteoblastomas" OR "Giant Osteoid Osteoma" OR "Giant Osteoid Osteomas" OR "Osteoid Osteomas" OR "Osteoid Osteoma" OR "Osteochondromas" OR "Osteocartilaginous Exostoses" OR "Osteocartilaginous Exostosis" OR "Chondrosteoma" OR "Chondrosteomas" OR "Giant Cell Tumor of Bone" OR "Bone Fibrous Dysplasia" OR "Bone Fibrous Dysplasias" OR "Fibrocystic Dysplasia of Bone" OR "Bone Fibrocystic Dysplasia" OR "Bone Fibrocystic Dysplasias" OR "Fibrocartilaginous Dysplasia of Bone" OR "Bone Fibrocartilaginous Dysplasia" OR "Bone Fibrocartilaginous Dysplasias" OR "Bone Dysplasias" OR "Bone Dysplasia" OR "Ossifying Fibroma" OR "Ossifying Fibromas" OR "Furcal Lesion" OR "Furcal lesions" OR "Periodontal disease" OR "Periodontal diesases" OR "Periodontitis" OR "Aggressive Periodontitis" OR "Periodontitis grade C" OR "Grade C periodontitis" OR "Periodontal Bone Losses" OR "Periodontal Bone Loss" OR "Osteoporosis" OR "Osteoporoses" OR "Post-Traumatic Osteoporoses" OR "Post-Traumatic Osteoporosis" OR "Senile Osteoporoses" OR "Senile Osteoporosis" OR "Age-Related Bone Loss" OR "Age-Related Bone Losses" OR "Age-Related Osteoporosis" OR "Age Related Osteoporosis" OR "Age-Related Osteoporoses" OR "Periapical Disease" OR "Periapical Diseases" OR "Furcation Defects" OR "Furcation Defect" OR "Alveolar Resorption" OR "Alveolar Resorptions" OR "Alveolar bone resorption" OR "Alveolar bone resorptions" OR "Osteoarthritis" OR "Osteoarthritides" OR "Osteoarthrosis" OR "Osteoarthroses" OR "Degenerative Arthritides" OR "Degenerative Arthritis" OR "Arthrosis" OR "Arthroses" OR "Osteoarthrosis Deformans") AND TI=("Jaws" OR "Jaw" OR "Jawbones" OR "Jawbone" OR "Mandibles" OR "Mandible" OR "Mandibular bone" OR "Mandibular bones" OR "Dentomaxillofacial" OR "Dento-maxillo-facial" OR "Dento maxillo facial" OR "Maxillofacial" OR "Maxillo-facial" OR "Maxillas" OR "Maxilla" OR "Mandibular bony structures" OR "Mandibular bony structure" OR "Maxillary Bone" OR "Maxillary Bones" OR "Maxillae" OR "Facial Bone" OR "Facial Bones" OR "Alveolar Bone Losses" OR "Alveolar Bone Loss" OR "Alveolar bone" OR "Alveolar bones" OR "Furcal" OR "Periapical" OR "Periapex") AND TI=("Radiomics" OR "Radiomics technique" OR "Radiomic" OR "Texture Analysis" OR "Texture Analysis TA" OR "Radiomic Machine Learning" OR "feature extraction")
Pubmed (Jan 12, 2022)	("radiography dental"[All Fields] OR "facial scanning"[All Fields] OR "Intraoral radiography"[All Fields] OR "intra oral radiography"[All Fields] OR "intra oral radiography"[All Fields] OR "Intraoral imaging"[All Fields] OR ("intra oral"[All Fields] AND ("image"[All Fields] OR "image s"[All Fields] OR "imaged"[All Fields] OR "imager"[All Fields] OR "imager s"[All Fields] OR "imagers"[All Fields] OR "images"[All Fields] OR "imaging"[All Fields] OR "imaging s"[All Fields] OR

"imagings"[All Fields])) OR ("intra"[All Fields] AND ("mouth"[MeSH Terms] OR "mouth"[All Fields] OR "oral"[All Fields]) AND ("image"[All Fields] OR "image s"[All Fields] OR "imaged"[All Fields] OR "imager"[All Fields] OR "imager s"[All Fields] OR "imagers"[All Fields] OR "images"[All Fields] OR "imaging"[All Fields] OR "imaging s"[All Fields] OR "imagings"[All Fields])) OR "intraoral scanning"[All Fields] OR "Periapical radiography"[All Fields] OR "Periapical imaging"[All Fields] OR "Extraoral radiography"[All Fields] OR "extra oral radiography"[All Fields] OR "extra oral radiography"[All Fields] OR "Extraoral imaging"[All Fields] OR "extra oral imaging"[All Fields] OR "extra oral imaging"[All Fields] OR "radiography bitewing"[All Fields] OR "Bitewing Radiography"[All Fields] OR "Bitewing Radiographies"[All Fields] OR ("radiography, bitewing"[MeSH Terms] OR ("radiography"[All Fields] AND "bitewing"[All Fields]) OR "Bitewing Radiography"[All Fields] OR ("radiographies"[All Fields] AND "bitewing"[All Fields])) OR "radiography dental digital"[All Fields] OR "radiography panoramic"[All Fields] OR "Dental Digital Radiography"[All Fields] OR "radiography dental digital"[All Fields] OR "digital radiography dental"[All Fields] OR "Dental panoramic radiographs"[All Fields] OR "Dental panoramic radiograph"[All Fields] OR "Pantomography"[All Fields] OR "Pantomographies"[All Fields] OR "Orthopantomography"[All Fields] OR "Orthopantomographies"[All Fields] OR "Panoramic Radiography"[All Fields] OR "Panoramic Radiographies"[All Fields] OR ("radiography, panoramic"[MeSH Terms] OR ("radiography"[All Fields] AND "panoramic"[All Fields]) OR "Panoramic Radiography"[All Fields] OR ("radiographies"[All Fields] AND "panoramic"[All Fields])) OR "computed tomography cone beam"[All Fields] OR "Cone Beam Computed Tomography"[All Fields] OR "cone beam computed tomography cbct"[All Fields] OR "CBCT"[All Fields] OR "CBCT scans"[All Fields] OR "ct scan cone beam"[All Fields] OR "ct scan cone beam"[All Fields] OR "ct scans cone beam"[All Fields] OR "Cone-Beam CT Scan"[All Fields] OR "Cone-Beam CT Scans"[All Fields] OR "scan cone beam ct"[All Fields] OR "scans cone beam ct"[All Fields] OR "tomography cone beam computed"[All Fields] OR "tomography cone beam computed"[All Fields] OR "tomography volume computed"[All Fields] OR "computed tomography volume"[All Fields] OR "Volume Computed Tomography"[All Fields] OR "Volumetric CT"[All Fields] OR "ct volumetric"[All Fields] OR "Volumetric Computed Tomography"[All Fields] OR "computed tomography volumetric"[All Fields] OR ("Cone Beam Computed Tomography"[MeSH Terms] OR ("cone beam"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "Cone Beam Computed Tomography"[All Fields] OR ("tomography"[All Fields] AND "volumetric"[All Fields] AND "computed"[All Fields])) OR "cat scan cone beam"[All Fields] OR "cat scan cone beam"[All Fields] OR ("Cone Beam Computed Tomography"[MeSH Terms] OR ("cone beam"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "Cone Beam Computed Tomography"[All Fields] OR ("cat"[All Fields] AND "scans"[All Fields] AND "cone"[All Fields] AND "beam"[All Fields])) OR "Cone-Beam CAT Scan"[All Fields] OR "Cone-Beam CAT Scans"[All Fields] OR ("Cone Beam Computed Tomography"[MeSH Terms] OR ("cone beam"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "Cone Beam Computed Tomography"[All Fields] OR ("scan"[All Fields] AND "cone"[All Fields] AND "beam"[All Fields] AND "cat"[All Fields])) OR ("Cone Beam Computed Tomography"[MeSH Terms] OR ("cone beam"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "Cone Beam Computed Tomography"[All Fields] OR ("scans"[All Fields] AND "cone"[All Fields] AND "beam"[All Fields] AND "cat"[All Fields])) OR ("Cone Beam Computed Tomography"[MeSH Terms] OR ("cone beam"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "Cone Beam Computed Tomography"[All Fields] OR ("cone"[All Fields] AND "beam"[All Fields] AND "computer"[All Fields] AND "assisted"[All Fields] AND "tomography"[All Fields])) OR ("Cone Beam Computed Tomography"[MeSH Terms] OR ("cone beam"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "Cone Beam Computed Tomography"[All Fields] OR ("computer"[All Fields] AND "assisted"[All Fields] AND "tomography"[All Fields] AND "cone"[All Fields] AND "beam"[All Fields])) OR ("Cone Beam Computed Tomography"[MeSH Terms] OR ("cone beam"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "Cone Beam Computed Tomography"[All Fields] OR ("cone"[All Fields] AND "beam"[All Fields] AND "computer"[All Fields] AND "assisted"[All Fields] AND "tomography"[All Fields])) OR ("Cone Beam Computed

Tomography"[MeSH Terms] OR ("cone beam"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "Cone Beam Computed Tomography"[All Fields] OR ("tomography"[All Fields] AND "cone"[All Fields] AND "beam"[All Fields] AND "computer"[All Fields] AND "assisted"[All Fields])) OR "cone beam computerized tomography"[All Fields] OR "computerized tomography cone beam"[All Fields] OR "cone beam computerized tomography"[All Fields] OR "tomography cone beam computerized"[All Fields] OR "cone beam ct"[All Fields] OR "ct cone beam"[All Fields] OR "cone beam ct"[All Fields] OR "Volume CT"[All Fields] OR "ct volume"[All Fields] OR "imaging magnetic resonance"[All Fields] OR "NMR Imaging"[All Fields] OR "imaging nmr"[All Fields] OR "tomography nmr"[All Fields] OR "tomography mr"[All Fields] OR "MR Tomography"[All Fields] OR "NMR Tomography"[All Fields] OR "steady state free precession mri"[All Fields] OR "steady state free precession mri"[All Fields] OR "Zeugmatography"[All Fields] OR "Magnetic Resonance Image"[All Fields] OR "image magnetic resonance"[All Fields] OR "Magnetic Resonance Images"[All Fields] OR "resonance image magnetic"[All Fields] OR "Magnetization Transfer Contrast Imaging"[All Fields] OR "MRI Scans"[All Fields] OR "MRI Scan"[All Fields] OR "scan mri"[All Fields] OR "scans mri"[All Fields] OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("tomography"[All Fields] AND "proton"[All Fields] AND "spin"[All Fields])) OR "Proton Spin Tomography"[All Fields] OR "fMRI"[All Fields] OR "mri functional"[All Fields] OR "Functional MRI"[All Fields] OR "Functional MRIs"[All Fields] OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("mris"[All Fields] AND "functional"[All Fields])) OR "Functional Magnetic Resonance Imaging"[All Fields] OR "magnetic resonance imaging functional"[All Fields] OR "Spin Echo Imaging"[All Fields] OR "echo imaging spin"[All Fields] OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("echo"[All Fields] AND "imagings"[All Fields] AND "spin"[All Fields])) OR "imaging spin echo"[All Fields] OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("imagings"[All Fields] AND "spin"[All Fields] AND "echo"[All Fields])) OR ("magnetic resonance imaging"[MeSH Terms] OR ("magnetic"[All Fields] AND "resonance"[All Fields] AND "imaging"[All Fields]) OR "magnetic resonance imaging"[All Fields] OR ("spin"[All Fields] AND "echo"[All Fields] AND "imagings"[All Fields])) OR "pet ct scan"[All Fields] OR "pet ct scans"[All Fields] OR "scan pet ct"[All Fields] OR "scans pet ct"[All Fields] OR "pet ct scan"[All Fields] OR "ct scan pet"[All Fields] OR "ct scans pet"[All Fields] OR "pet ct scans"[All Fields] OR "scan pet ct"[All Fields] OR "scans pet ct"[All Fields] OR "CT PET"[All Fields] OR "Positron Emission Tomography-Computed Tomography"[All Fields] OR "PET-CT"[All Fields] OR "CT PET Scan"[All Fields] OR "CT PET Scans"[All Fields] OR "pet scan ct"[All Fields] OR "pet scans ct"[All Fields] OR ("Positron Emission Tomography-Computed Tomography"[MeSH Terms] OR ("positron"[All Fields] AND "emission"[All Fields] AND "tomography"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "Positron Emission Tomography-Computed Tomography"[All Fields] OR ("scan"[All Fields] AND "ct"[All Fields] AND "pet"[All Fields])) OR ("Positron Emission Tomography-Computed Tomography"[MeSH Terms] OR ("positron"[All Fields] AND "emission"[All Fields] AND "tomography"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "Positron Emission Tomography-Computed Tomography"[All Fields] OR ("scans"[All Fields] AND "ct"[All Fields] AND "pet"[All Fields])) OR "imaging radionuclide"[All Fields] OR "Radioisotope Scanning"[All Fields] OR ("radionuclide imaging"[MeSH Terms] OR ("radionuclide"[All Fields] AND "imaging"[All Fields]) OR "radionuclide imaging"[All Fields] OR "scintigraphies"[All Fields] OR "scintigraphy"[All Fields]) OR "Gamma Camera Imaging"[All Fields] OR "imaging gamma camera"[All Fields] OR "scanning radioisotope"[All Fields] OR ("radionuclide imaging"[MeSH Terms] OR ("radionuclide"[All Fields] AND "imaging"[All Fields]) OR "radionuclide imaging"[All Fields] OR "scintiphotography"[All Fields]) OR "SPECT CT"[All Fields] OR "CT SPECT Scan"[All Fields] OR "CT SPECT Scans"[All Fields] OR "spect scan ct"[All

Fields] OR ("single photon emission computed tomography computed tomography"[MeSH Terms] OR ("single"[All Fields] AND "photon"[All Fields] AND "emission"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "single photon emission computed tomography computed tomography"[All Fields] OR ("spect"[All Fields] AND "scans"[All Fields] AND "ct"[All Fields])) OR ("single photon emission computed tomography computed tomography"[MeSH Terms] OR ("single"[All Fields] AND "photon"[All Fields] AND "emission"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "single photon emission computed tomography computed tomography"[All Fields] OR ("scan"[All Fields] AND "ct"[All Fields] AND "spect"[All Fields])) OR ("single photon emission computed tomography computed tomography"[MeSH Terms] OR ("single"[All Fields] AND "photon"[All Fields] AND "emission"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "single photon emission computed tomography computed tomography"[All Fields] OR ("scans"[All Fields] AND "ct"[All Fields] AND "spect"[All Fields])) OR "CT SPECT"[All Fields] OR ("single photon emission computed tomography computed tomography"[MeSH Terms] OR ("single"[All Fields] AND "photon"[All Fields] AND "emission"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "single photon emission computed tomography computed tomography"[All Fields] OR ("ct"[All Fields] AND "spects"[All Fields])) OR "SPECT CT"[All Fields] OR ("single photon emission computed tomography computed tomography"[MeSH Terms] OR ("single"[All Fields] AND "photon"[All Fields] AND "emission"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "single photon emission computed tomography computed tomography"[All Fields] OR ("spects"[All Fields] AND "ct"[All Fields])) OR "SPECT CT Scan"[All Fields] OR "ct scan spect"[All Fields] OR "ct scans spect"[All Fields] OR "SPECT CT Scans"[All Fields] OR "scan spect ct"[All Fields] OR "scans spect ct"[All Fields] OR "computed tomography multidetector"[All Fields] OR "tomography multidetector computed"[All Fields] OR "Multisection Computed Tomography"[All Fields] OR ("multidetector computed tomography"[MeSH Terms] OR ("multidetector"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "multidetector computed tomography"[All Fields] OR ("computed"[All Fields] AND "tomography"[All Fields] AND "multisection"[All Fields])) OR "Dual-energy CT"[All Fields] OR "Multidetector row CT"[All Fields] OR "Perfusion CT"[All Fields] OR ("multidetector computed tomography"[MeSH Terms] OR ("multidetector"[All Fields] AND "computed"[All Fields] AND "tomography"[All Fields]) OR "multidetector computed tomography"[All Fields] OR ("tomography"[All Fields] AND "multisection"[All Fields] AND "computed"[All Fields])) OR "Multislice Computed Tomography"[All Fields] OR "computed tomography multislice"[All Fields] OR "tomography multislice computed"[All Fields] OR "multidetector row computed tomography"[All Fields] OR "computed tomography multidetector row"[All Fields] OR "multidetector row computed tomography"[All Fields] OR "tomography multidetector row computed"[All Fields] OR "Diagnostic imaging"[All Fields] OR "imaging diagnostic"[All Fields] OR "Medical Imaging"[All Fields] OR "imaging medical"[All Fields]) AND ("Bone Neoplasm"[All Fields] OR "neoplasm bone"[All Fields] OR "neoplasms bone"[All Fields] OR "Bone Cancer"[All Fields] OR "Cancer of the Bone"[All Fields] OR "Cancer of Bone"[All Fields] OR "Bone Lesion"[All Fields] OR "osseous pathology"[All Fields] OR "bone pathology"[All Fields] OR "osseous pathologies"[All Fields] OR "bone pathologies"[All Fields] OR "Bone Lesions"[All Fields] OR "Osseous Lesion"[All Fields] OR "Osseous Lesions"[All Fields] OR ("cysts"[MeSH Terms] OR "cysts"[All Fields] OR "cyst"[All Fields] OR "neurofibroma"[MeSH Terms] OR "neurofibroma"[All Fields] OR "neurofibromas"[All Fields] OR "tumor s"[All Fields] OR "tumoral"[All Fields] OR "tumorous"[All Fields] OR "tumour"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "tumor"[All Fields] OR "tumour s"[All Fields] OR "tumoural"[All Fields] OR "tumourous"[All Fields] OR "tumours"[All Fields] OR "tumors"[All Fields]) OR ("cyst s"[All Fields] OR "cystes"[All Fields] OR "cysts"[MeSH Terms] OR "cysts"[All Fields]) OR ("cysts"[MeSH Terms] OR "cysts"[All Fields] OR "cyst"[All Fields] OR "neurofibroma"[MeSH Terms] OR "neurofibroma"[All Fields] OR "neurofibromas"[All

Fields] OR "tumor s"[All Fields] OR "tumoral"[All Fields] OR "tumorous"[All Fields] OR "tumour"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "tumor"[All Fields] OR "tumour s"[All Fields] OR "tumoural"[All Fields] OR "tumourous"[All Fields] OR "tumours"[All Fields] OR "tumors"[All Fields]) OR ("neoplasm s"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "neoplasm"[All Fields]) OR ("cysts"[MeSH Terms] OR "cysts"[All Fields] OR "cyst"[All Fields] OR "neurofibroma"[MeSH Terms] OR "neurofibroma"[All Fields] OR "neurofibromas"[All Fields] OR "tumor s"[All Fields] OR "tumoral"[All Fields] OR "tumorous"[All Fields] OR "tumour"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "tumor"[All Fields] OR "tumour s"[All Fields] OR "tumoural"[All Fields] OR "tumourous"[All Fields] OR "tumours"[All Fields] OR "tumors"[All Fields]) OR ("neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "neoplasia"[All Fields] OR "neoplasias"[All Fields]) OR ("neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "neoplasia"[All Fields] OR "neoplasias"[All Fields]) OR ("cancer s"[All Fields] OR "cancerated"[All Fields] OR "canceration"[All Fields] OR "cancerization"[All Fields] OR "cancerized"[All Fields] OR "cancerous"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "cancer"[All Fields] OR "cancers"[All Fields]) OR ("cancer s"[All Fields] OR "cancerated"[All Fields] OR "canceration"[All Fields] OR "cancerization"[All Fields] OR "cancerized"[All Fields] OR "cancerous"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "cancer"[All Fields] OR "cancers"[All Fields]) OR "Malignant Neoplasm"[All Fields] OR ("malign"[All Fields] OR "malignance"[All Fields] OR "malignances"[All Fields] OR "malignant"[All Fields] OR "malignants"[All Fields] OR "malignities"[All Fields] OR "malignity"[All Fields] OR "malignization"[All Fields] OR "malignized"[All Fields] OR "maligns"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "malignancies"[All Fields] OR "malignancy"[All Fields]) OR ("malign"[All Fields] OR "malignance"[All Fields] OR "malignances"[All Fields] OR "malignant"[All Fields] OR "malignants"[All Fields] OR "malignities"[All Fields] OR "malignity"[All Fields] OR "malignization"[All Fields] OR "malignized"[All Fields] OR "maligns"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "malignancies"[All Fields] OR "malignancy"[All Fields]) OR "Malignant Neoplasms"[All Fields] OR "neoplasm malignant"[All Fields] OR "neoplasms malignant"[All Fields] OR "Benign Neoplasms"[All Fields] OR "Benign Neoplasm"[All Fields] OR "neoplasms benign"[All Fields] OR "neoplasm benign"[All Fields] OR "fibro-osseous lesions"[All Fields] OR "fibro-osseous lesions"[All Fields] OR "fibroosseous lesions"[All Fields] OR "fibroosseous lesion"[All Fields] OR "Inflammatory lesions"[All Fields] OR "Inflammatory lesion"[All Fields] OR "Bone Neoplasm"[All Fields] OR "neoplasm bone"[All Fields] OR "neoplasms bone"[All Fields] OR "Bone Cancer"[All Fields] OR "Cancer of the Bone"[All Fields] OR "Cancer of Bone"[All Fields] OR "Giant Cell Tumor of Bone"[All Fields] OR "Bone Lesion"[All Fields] OR "Bone Lesions"[All Fields] OR "Osseous Lesion"[All Fields] OR "Osseous Lesions"[All Fields] OR ("cherubism"[MeSH Terms] OR "cherubism"[All Fields] OR ("familial"[All Fields] AND "fibrous"[All Fields] AND "dysplasia"[All Fields] AND "jaw"[All Fields])) OR "Familial Multilocular Cystic Disease of the Jaws"[All Fields] OR ("cherubism"[MeSH Terms] OR "cherubism"[All Fields] OR ("familial"[All Fields] AND "benign"[All Fields] AND "giant"[All Fields] AND "cell"[All Fields] AND "tumor"[All Fields] AND "jaw"[All Fields])) OR ("osteomyelities"[All Fields] OR "osteomyelitis"[MeSH Terms] OR "osteomyelitis"[All Fields] OR "osteomyelitides"[All Fields]) OR ("osteonecrosis"[MeSH Terms] OR "osteonecrosis"[All Fields] OR "osteonecroses"[All Fields]) OR ("osteonecrosis"[MeSH Terms] OR "osteonecrosis"[All Fields] OR "osteonecroses"[All Fields]) OR "Bone Necrosis"[All Fields] OR "Bone Necroses"[All Fields] OR "necroses bone"[All Fields] OR "necrosis bone"[All Fields] OR ("osteonecrosis"[MeSH Terms] OR "osteonecrosis"[All Fields] OR ("necrosis"[All Fields] AND "avascular"[All Fields] AND "bone"[All Fields])) OR "Avascular Necrosis of Bone"[All Fields] OR "Bone Avascular Necrosis"[All Fields] OR ("osteonecrosis"[MeSH Terms] OR "osteonecrosis"[All Fields] OR ("necrosis"[All Fields] AND "aseptic"[All Fields] AND "bone"[All Fields])) OR "Aseptic Necrosis of Bone"[All Fields] OR "Bone Aseptic Necrosis"[All Fields] OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR "bisphosphonate induced osteonecrosis of the jaw"[All Fields] OR "bisphosphonate induced osteonecrosis of the jaw"[All Fields] OR "bisphosphonate induced osteonecrosis of the jaws"[All Fields] OR "bisphosphonate induced osteonecrosis of the jaws"[All Fields] OR "bisphosphonate related osteonecrosis of the jaw"[All Fields] OR "bisphosphonate related osteonecrosis of the jaw"[All Fields] OR "osteonecrosis of the jaws bisphosphonate associated"[All Fields] OR "osteonecrosis of the jaws bisphosphonate associated"[All Fields] OR "osteonecrosis of the jaw bisphosphonate related"[All Fields] OR "osteonecrosis of the jaw bisphosphonate related"[All Fields] OR ("Bisphosphonate Associated Osteonecrosis of the Jaw"[MeSH Terms] OR ("bisphosphonate associated"[All Fields] AND "osteonecrosis"[All Fields] AND "jaw"[All Fields]) OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR ("osteonecrosis"[All Fields] AND "jaws"[All Fields] AND "bisphosphonate"[All Fields] AND "induced"[All Fields])) OR ("Bisphosphonate Associated Osteonecrosis of the Jaw"[MeSH Terms] OR ("bisphosphonate associated"[All Fields] AND "osteonecrosis"[All Fields] AND "jaw"[All Fields]) OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR ("osteonecrosis"[All Fields] AND "jaws"[All Fields] AND "bisphosphonate"[All Fields] AND "induced"[All Fields])) OR ("Bisphosphonate Associated Osteonecrosis of the Jaw"[MeSH Terms] OR ("bisphosphonate associated"[All Fields] AND "osteonecrosis"[All Fields] AND "jaw"[All Fields]) OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR ("osteonecrosis"[All Fields] AND "jaws"[All Fields] AND "bisphosphonate"[All Fields] AND "related"[All Fields])) OR ("Bisphosphonate Associated Osteonecrosis of the Jaw"[MeSH Terms] OR ("bisphosphonate associated"[All Fields] AND "osteonecrosis"[All Fields] AND "jaw"[All Fields]) OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR ("osteonecrosis"[All Fields] AND "jaws"[All Fields] AND "bisphosphonate"[All Fields] AND "related"[All Fields])) OR ("Bisphosphonate Associated Osteonecrosis of the Jaw"[MeSH Terms] OR ("bisphosphonate associated"[All Fields] AND "osteonecrosis"[All Fields] AND "jaw"[All Fields]) OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR ("osteonecrosis"[All Fields] AND "jaw"[All Fields] AND "bisphosphonate"[All Fields] AND "associated"[All Fields])) OR ("Bisphosphonate Associated Osteonecrosis of the Jaw"[MeSH Terms] OR ("bisphosphonate associated"[All Fields] AND "osteonecrosis"[All Fields] AND "jaw"[All Fields]) OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR ("osteonecrosis"[All Fields] AND "jaw"[All Fields] AND "bisphosphonate"[All Fields] AND "associated"[All Fields])) OR "bisphosphonate associated osteonecrosis of the jaws"[All Fields] OR "bisphosphonate associated osteonecrosis of the jaws"[All Fields] OR "osteonecrosis of the jaw bisphosphonate induced"[All Fields] OR "osteonecrosis of the jaw bisphosphonate induced"[All Fields] OR "bisphosphonate associated osteonecrosis"[All Fields] OR "bisphosphonate associated osteonecrosis"[All Fields] OR ("Bisphosphonate Associated Osteonecrosis of the Jaw"[MeSH Terms] OR ("bisphosphonate associated"[All Fields] AND "osteonecrosis"[All Fields] AND "jaw"[All Fields]) OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR ("bisphosphonate"[All Fields] AND "associated"[All Fields] AND "osteonecroses"[All Fields])) OR ("Bisphosphonate Associated Osteonecrosis of the Jaw"[MeSH Terms] OR ("bisphosphonate associated"[All Fields] AND "osteonecrosis"[All Fields] AND "jaw"[All Fields]) OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR ("osteonecroses"[All Fields] AND "bisphosphonate"[All Fields] AND "associated"[All Fields])) OR "osteonecrosis bisphosphonate associated"[All Fields] OR "Bisphosphonate Osteonecrosis"[All Fields] OR ("Bisphosphonate Associated Osteonecrosis of the Jaw"[MeSH Terms] OR ("bisphosphonate associated"[All Fields] AND "osteonecrosis"[All Fields] AND "jaw"[All Fields]) OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR ("bisphosphonate"[All Fields] AND "osteonecroses"[All Fields])) OR ("Bisphosphonate Associated Osteonecrosis of the Jaw"[MeSH Terms] OR ("bisphosphonate associated"[All Fields] AND "osteonecrosis"[All Fields] AND "jaw"[All Fields]) OR "Bisphosphonate Associated Osteonecrosis of the Jaw"[All Fields] OR ("osteonecroses"[All Fields] AND "bisphosphonate"[All Fields])) OR "osteonecrosis bisphosphonate"[All Fields] OR ("osteosarcoma"[MeSH Terms] OR "osteosarcoma"[All Fields] OR "osteosarcomas"[All Fields]) OR "Osteosarcoma Tumor"[All Fields] OR "Osteosarcoma Tumors"[All Fields] OR "tumor osteosarcoma"[All Fields] OR "tumors osteosarcoma"[All Fields] OR "sarcoma osteogenic"[All Fields] OR "Osteogenic Sarcomas"[All Fields] OR "sarcomas osteogenic"[All Fields] OR "Osteogenic Sarcoma"[All Fields] OR "Ewing Sarcoma"[All Fields] OR "Sarcoma Ewing"[All Fields]

OR ("osteoblastoma"[MeSH Terms] OR "osteoblastoma"[All Fields] OR "osteoblastomas"[All Fields]) OR "osteoma giant osteoid"[All Fields] OR "Giant Osteoid Osteoma"[All Fields] OR ("osteoblastoma"[MeSH Terms] OR "osteoblastoma"[All Fields] OR ("giant"[All Fields] AND "osteoid"[All Fields] AND "osteomas"[All Fields])) OR "osteoid osteoma giant"[All Fields] OR "osteoid osteomas giant"[All Fields] OR ("osteoblastoma"[MeSH Terms] OR "osteoblastoma"[All Fields] OR ("osteomas"[All Fields] AND "giant"[All Fields] AND "osteoid"[All Fields])) OR "Osteoid Osteomas"[All Fields] OR "osteomas osteoid"[All Fields] OR "Osteoid Osteoma"[All Fields] OR ("osteochondroma"[MeSH Terms] OR "osteochondroma"[All Fields] OR "osteochondromas"[All Fields]) OR ("osteochondroma"[MeSH Terms] OR "osteochondroma"[All Fields] OR ("exostosis"[All Fields] AND "osteocartilaginous"[All Fields])) OR ("osteochondroma"[MeSH Terms] OR "osteochondroma"[All Fields] OR ("exostoses"[All Fields] AND "osteocartilaginous"[All Fields])) OR "Osteocartilaginous Exostoses"[All Fields] OR "Osteocartilaginous Exostosis"[All Fields] OR ("osteochondroma"[MeSH Terms] OR "osteochondroma"[All Fields]) OR ("osteochondroma"[MeSH Terms] OR "osteochondroma"[All Fields]) OR "Giant Cell Tumor of Bone"[All Fields] OR "Bone Fibrous Dysplasia"[All Fields] OR "Bone Fibrous Dysplasias"[All Fields] OR ("fibrous dysplasia of bone"[MeSH Terms] OR ("fibrous"[All Fields] AND "dysplasia"[All Fields] AND "bone"[All Fields]) OR "fibrous dysplasia of bone"[All Fields] OR ("fibrocystic"[All Fields] AND "dysplasia"[All Fields] AND "bone"[All Fields])) OR ("fibrous dysplasia of bone"[MeSH Terms] OR ("fibrous"[All Fields] AND "dysplasia"[All Fields] AND "bone"[All Fields]) OR "fibrous dysplasia of bone"[All Fields] OR ("bone"[All Fields] AND "fibrocystic"[All Fields] AND "dysplasia"[All Fields])) OR ("fibrous dysplasia of bone"[MeSH Terms] OR ("fibrous"[All Fields] AND "dysplasia"[All Fields] AND "bone"[All Fields]) OR "fibrous dysplasia of bone"[All Fields] OR ("bone"[All Fields] AND "fibrocystic"[All Fields] AND "dysplasias"[All Fields])) OR "Fibrocartilaginous Dysplasia of Bone"[All Fields] OR "Bone Fibrocartilaginous Dysplasia"[All Fields] OR ("fibrous dysplasia of bone"[MeSH Terms] OR ("fibrous"[All Fields] AND "dysplasia"[All Fields] AND "bone"[All Fields]) OR "fibrous dysplasia of bone"[All Fields] OR ("bone"[All Fields] AND "fibrocartilaginous"[All Fields] AND "dysplasias"[All Fields])) OR "Bone Dysplasias"[All Fields] OR "Bone Dysplasia"[All Fields] OR "dysplasia bone"[All Fields] OR "dysplasias bone"[All Fields] OR ("fibroma, ossifying"[MeSH Terms] OR ("fibroma"[All Fields] AND "ossifying"[All Fields]) OR "Ossifying Fibroma"[All Fields] OR ("fibromas"[All Fields] AND "ossifying"[All Fields])) OR "Ossifying Fibroma"[All Fields] OR "Ossifying Fibromas"[All Fields] OR "Furcal Lesion"[All Fields] OR "Furcal lesions"[All Fields] OR "Periodontal disease"[All Fields] OR (("periodontal"[All Fields] OR "periodontally"[All Fields] OR "periodontically"[All Fields] OR "periodontics"[MeSH Terms] OR "periodontics"[All Fields] OR "periodontic"[All Fields] OR "periodontitis"[MeSH Terms] OR "periodontitis"[All Fields] OR "periodontitides"[All Fields]) AND "diesases"[All Fields]) OR "disease periodontal"[All Fields] OR "diseases periodontal"[All Fields] OR ("periodontal"[All Fields] OR "periodontally"[All Fields] OR "periodontically"[All Fields] OR "periodontics"[MeSH Terms] OR "periodontics"[All Fields] OR "periodontic"[All Fields] OR "periodontitis"[MeSH Terms] OR "periodontitis"[All Fields] OR "periodontitides"[All Fields]) OR "periodontitis aggressive"[All Fields] OR "Aggressive Periodontitis"[All Fields] OR "Periodontitis grade C"[All Fields] OR "Grade C periodontitis"[All Fields] OR "bone loss periodontal"[All Fields] OR ("Alveolar Bone Loss"[MeSH Terms] OR ("alveolar"[All Fields] AND "bone"[All Fields] AND "loss"[All Fields]) OR "Alveolar Bone Loss"[All Fields] OR ("bone"[All Fields] AND "losses"[All Fields] AND "periodontal"[All Fields])) OR "Periodontal Bone Losses"[All Fields] OR "Periodontal Bone Loss"[All Fields] OR ("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR "osteoporoses"[All Fields] OR "osteoporosis, postmenopausal"[MeSH Terms] OR ("osteoporosis"[All Fields] AND "postmenopausal"[All Fields]) OR "postmenopausal osteoporosis"[All Fields]) OR (("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR "osteoporoses"[All Fields] OR "osteoporosis, postmenopausal"[MeSH Terms] OR ("osteoporosis"[All Fields] AND "postmenopausal"[All Fields]) OR "postmenopausal osteoporosis"[All Fields]) AND ("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR ("osteoporosis"[All Fields] AND "post"[All Fields] AND "traumatic"[All Fields]))) OR ("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR ("osteoporosis"[All Fields] AND "post"[All Fields] AND "traumatic"[All

Fields])) OR ("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR ("post"[All Fields] AND "traumatic"[All Fields] AND "osteoporoses"[All Fields])) OR "Post-Traumatic Osteoporosis"[All Fields] OR "osteoporosis senile"[All Fields] OR ("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR ("osteoporoses"[All Fields] AND "senile"[All Fields])) OR ("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR ("senile"[All Fields] AND "osteoporoses"[All Fields])) OR ("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR ("osteoporosis"[All Fields] AND "involutional"[All Fields])) OR "Senile Osteoporosis"[All Fields] OR "osteoporosis age related"[All Fields] OR "osteoporosis age related"[All Fields] OR "bone loss age related"[All Fields] OR "Age-Related Bone Loss"[All Fields] OR "Age-Related Bone Losses"[All Fields] OR "bone loss age related"[All Fields] OR ("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR ("bone"[All Fields] AND "losses"[All Fields] AND "age"[All Fields] AND "related"[All Fields])) OR "age related osteoporosis"[All Fields] OR "age related osteoporosis"[All Fields] OR "Age-Related Osteoporoses"[All Fields] OR ("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR ("osteoporoses"[All Fields] AND "age"[All Fields] AND "related"[All Fields])) OR "disease periapical"[All Fields] OR "diseases periapical"[All Fields] OR "Periapical Disease"[All Fields] OR "defect furcation"[All Fields] OR "defects furcation"[All Fields] OR "Furcation Defect"[All Fields] OR "Alveolar Resorption"[All Fields] OR ("Alveolar Bone Loss"[MeSH Terms] OR ("alveolar"[All Fields] AND "bone"[All Fields] AND "loss"[All Fields]) OR "Alveolar Bone Loss"[All Fields] OR ("alveolar"[All Fields] AND "resorptions"[All Fields])) OR "resorption alveolar"[All Fields] OR ("Alveolar Bone Loss"[MeSH Terms] OR ("alveolar"[All Fields] AND "bone"[All Fields] AND "loss"[All Fields]) OR "Alveolar Bone Loss"[All Fields] OR ("resorptions"[All Fields] AND "alveolar"[All Fields])) OR "Alveolar bone resorption"[All Fields] OR (("alveolar"[All Fields] OR "alveolarization"[All Fields] OR "alveolars"[All Fields]) AND ("bone resorption"[MeSH Terms] OR ("bone"[All Fields] AND "resorption"[All Fields]) OR "bone resorption"[All Fields] OR ("bone"[All Fields] AND "resorptions"[All Fields]) OR "bone resorptions"[All Fields])) OR ("osteoarthritis"[MeSH Terms] OR "osteoarthritis"[All Fields] OR "osteoarthritides"[All Fields]) OR ("osteoarthritis"[MeSH Terms] OR "osteoarthritis"[All Fields] OR "osteoarthritides"[All Fields]) OR ("osteoarthritis"[MeSH Terms] OR "osteoarthritis"[All Fields] OR "osteoarthrosis"[All Fields]) OR ("osteoarthritis"[MeSH Terms] OR "osteoarthritis"[All Fields] OR "osteoarthroses"[All Fields]) OR "arthritis degenerative"[All Fields] OR ("osteoarthritis"[MeSH Terms] OR "osteoarthritis"[All Fields] OR ("arthritides"[All Fields] AND "degenerative"[All Fields])) OR "Degenerative Arthritides"[All Fields] OR "Degenerative Arthritis"[All Fields] OR ("joint diseases"[MeSH Terms] OR ("joint"[All Fields] AND "diseases"[All Fields]) OR "joint diseases"[All Fields] OR "arthrosis"[All Fields]) OR ("arthrosic"[All Fields] OR "osteoarthritis"[MeSH Terms] OR "osteoarthritis"[All Fields] OR "arthroses"[All Fields]) OR "Osteoarthrosis Deformans"[All Fields]) AND ("jaw"[MeSH Terms] OR "jaw"[All Fields] OR "jaws"[All Fields] OR ("jaw"[MeSH Terms] OR "jaw"[All Fields]) OR ("jawbone"[All Fields] OR "jawbones"[All Fields]) OR ("jawbone"[All Fields] OR "jawbones"[All Fields]) OR ("mandible"[MeSH Terms] OR "mandible"[All Fields] OR "mandibles"[All Fields] OR "mandible s"[All Fields]) OR ("mandible"[MeSH Terms] OR "mandible"[All Fields] OR "mandibles"[All Fields] OR "mandible s"[All Fields]) OR "Mandibular bone"[All Fields] OR "Mandibular bones"[All Fields] OR "Dentomaxillofacial"[All Fields] OR "dento maxillo facial"[All Fields] OR "dento maxillo facial"[All Fields] OR "Maxillofacial"[All Fields] OR "Maxillo-facial"[All Fields] OR ("maxilla"[MeSH Terms] OR "maxilla"[All Fields] OR "Maxillae"[All Fields] OR "maxillas"[All Fields]) OR ("maxilla"[MeSH Terms] OR "maxilla"[All Fields] OR "Maxillae"[All Fields] OR "maxillas"[All Fields]) OR "Mandibular bony structures"[All Fields] OR (("mandible"[MeSH Terms] OR "mandible"[All Fields] OR "mandibular"[All Fields] OR "mandibulars"[All Fields]) AND "bony"[All Fields] AND ("structural"[All Fields] OR "structurally"[All Fields] OR "structurals"[All Fields] OR "structuration"[All Fields] OR "structurations"[All Fields] OR "structure"[All Fields] OR "structure s"[All Fields] OR "structured"[All Fields] OR "structures"[All Fields] OR "structuring"[All Fields])) OR "Maxillary Bone"[All Fields] OR "bone maxillary"[All Fields] OR "bones maxillary"[All Fields] OR "Maxillary Bones"[All Fields] OR "Maxillae"[All Fields] OR "bone facial"[All Fields] OR "bones facial"[All Fields] OR "Facial Bone"[All Fields] OR "Facial Bones"[All Fields] OR "bone loss alveolar"[All

	Fields] OR "Alveolar Bone Losses"[All Fields] OR "Alveolar Bone Loss"[All Fields] OR (("bone and bones"[MeSH Terms] OR ("bone"[All Fields] AND "bones"[All Fields]) OR "bone and bones"[All Fields] OR "bone"[All Fields]) AND "losses"[All Fields] AND ("alveolar"[All Fields] OR "alveolarization"[All Fields] OR "alveolars"[All Fields])) OR "Alveolar bone"[All Fields] OR "Alveolar bones"[All Fields] OR "Furcal"[All Fields] OR ("periapical"[All Fields] OR "periapically"[All Fields] OR "periapicals"[All Fields]) OR "Periapex"[All Fields]) AND ("radiomic"[All Fields] OR "radiomics"[All Fields] OR "Radiomics technique"[All Fields] OR ("radiomic"[All Fields] OR "radiomics"[All Fields]) OR "Texture Analysis"[All Fields] OR "texture analysis ta"[All Fields] OR "Radiomic Machine Learning"[All Fields] OR "feature extraction"[All Fields])
Scopus (Jan 12, 2022)	TITLE-ABS-KEY ("Dental Radiography" OR "facial scanning" OR "Intraoral radiography" OR "Intra-oral radiography" OR "Intra oral radiography" OR "Intraoral imaging" OR "Intra-oral imaging" OR "Intra oral imaging" OR "intraoral scanning" OR "Periapical radiography" OR "Periapical imaging" OR "Extraoral radiography" OR "Extra-oral radiography" OR "Extra oral radiography" OR "Extraoral imaging" OR "Extra-oral imaging" OR "Extra oral imaging" OR "Bitewing Radiography" OR "Bitewing Radiographies" OR "Dental Digital Radiography" OR "Dental panoramic radiographs" OR "Dental panoramic radiograph" OR "Pantomography" OR "Pantomographies" OR "Orthopantomography" OR "Orthopantomographies" OR "Panoramic Radiography" OR "Panoramic Radiographies" OR "Cone Beam Computed Tomography" OR "Cone-beam computed tomography (CBCT)" OR cbct OR "CBCT scans" OR "Cone-Beam CT Scan" OR "Cone-Beam CT Scans" OR "Volume Computed Tomography" OR "Volumetric CT" OR "Volumetric Computed Tomography" OR "Cone-Beam CAT Scan" OR "Cone-Beam CAT Scans" OR "Cone-Beam Computer-Assisted Tomography" OR "Cone Beam Computer Assisted Tomography" OR "Cone-Beam Computerized Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Beam CT" OR "Cone Beam CT" OR "Volume CT" OR "NMR Imaging" OR "MR Tomography" OR "NMR Tomography" OR "Steady-State Free Precession MRI" OR "Steady State Free Precession MRI" OR "Zeugmatography" OR "Magnetic Resonance Image" OR "Magnetic Resonance Images" OR "Magnetization Transfer Contrast Imaging" OR "MRI Scans" OR "MRI Scan" OR "Proton Spin Tomography" OR "fMRI" OR "Functional MRI" OR "Functional MRIs" OR "Functional Magnetic Resonance Imaging" OR "Spin Echo Imaging" OR "Spin Echo Imagings" OR "PET-CT Scan" OR "PET-CT Scans" OR "PET CT Scan" OR "PET CT Scans" OR "CT PET" OR "Positron Emission Tomography-Computed Tomography" OR "PET-CT" OR "CT PET Scan" OR "CT PET Scans" OR "Radioisotope Scanning" OR scintigraphy OR "Gamma Camera Imaging" OR scintiphotography OR "SPECT CT" OR "CT SPECT Scan" OR "CT SPECT Scans" OR "CT SPECT" OR "CT SPECTs" OR "SPECT CT Scan" OR "SPECT CT Scans" OR "Multisection Computed Tomography" OR "Dual-energy CT" OR "Multidetector row CT" OR "Perfusion CT" OR "Multislice Computed Tomography" OR "Multidetector-Row Computed Tomography" OR "Multidetector Row

Computed Tomography" OR "Diagnostic imaging" OR "Medical Imaging") AND ("Bone Neoplasm" OR "Bone Cancer" OR "Cancer of the Bone" OR "Cancer of Bone" OR "Bone Lesion" OR "Bone Lesions" OR "osseous pathology" OR "bone pathology" OR "osseous pathologies" OR "bone pathologies" OR "Osseous Lesion" OR "Osseous Lesions" OR "Cyst" OR "cysts" OR "Tumor" OR "Neoplasm" OR "Tumors" OR "N eoplasia" OR "Neoplasias" OR "Cancer" OR "Cancers" OR "Malignant Neoplasm" OR "Malignancy" OR "Malignancies" OR "Malignant Neoplasms" OR "Benign Neoplasms" OR "Benign Neoplasm" OR "fibro-osseous lesions" OR "fibro-osseous lesions" OR "fibroosseous lesions" OR "fibroosseous lesion" OR "Inflammatory lesions" OR "Inflammatory lesion" OR "Giant Cell Tumor of Bone" OR "Familial Fibrous Dysplasia of Jaw" OR "Familial Multilocular Cystic Disease of the Jaws" OR "Familial Benign Giant-Cell Tumor of the Jaw" OR "Osteomyelitis" OR "Osteonecroses" OR "Osteonecrosis" OR "Bone Necrosis" OR "Bone Necroses" OR "Avascular Necrosis of Bone" OR "Bone Avascular Necrosis" OR "Aseptic Necrosis of Bone" OR "Bone Aseptic Necrosis" OR "Bisphosphonate Associated Osteonecrosis of the Jaw" OR "Bisphosphonate-Induced Osteonecrosis of the Jaw" OR "Bisphosphonate Induced Osteonecrosis of the Jaw" OR "Bisphosphonate-Induced Osteonecrosis of the Jaws" OR "Bisphosphonate Induced Osteonecrosis of the Jaws" OR "Bisphosphonate-Related Osteonecrosis of the Jaw" OR "Bisphosphonate Related Osteonecrosis of the Jaw" OR "Bisphosphonate-Associated Osteonecrosis of the Jaws" OR "Bisphosphonate Associated Osteonecrosis of the Jaws" OR "Bisphosphonate-Associated Osteonecrosis" OR "Bisphosphonate Associated Osteonecrosis" OR "Bisphosphonate-Associated Osteonecroses" OR "Bisphosphonate Osteonecrosis" OR "Bisphosphonate Osteonecroses" OR "Osteosarcomas" OR "Osteosarcoma Tumor" OR "Osteosarcoma Tumors" OR "Osteogenic Sarcomas" OR "Osteogenic Sarcoma" OR "Ewing Sarcoma" OR "Sarcoma Ewing" OR "Osteoblastomas" OR "Giant Osteoid Osteoma" OR "Giant Osteoid Osteomas" OR "Osteoid Osteomas" OR "Osteoid Osteoma" OR "Osteochondromas" OR "Osteocartilaginous Exostoses" OR "Osteocartilaginous Exostosis" OR "Chondrosteoma" OR "Chondrosteomas" OR "Giant Cell Tumor of Bone" OR "Bone Fibrous Dysplasia" OR "Bone Fibrous Dysplasias" OR "Fibrocystic Dysplasia of Bone" OR "Bone Fibrocystic Dysplasia" OR "Bone Fibrocystic Dysplasias" OR "Fibrocartilaginous Dysplasia of Bone" OR "Bone Fibrocartilaginous Dysplasia" OR "Bone Fibrocartilaginous Dysplasias" OR "Bone Dysplasias" OR "Bone Dysplasia" OR "Ossifying Fibroma" OR "Ossifying Fibromas" OR "Furcal Lesion" OR "Furcal lesions" OR "Periodontal disease" OR "Periodontal diesases" OR "Periodontitis" OR "Aggressive Periodontitis" OR "Periodontitis grade C" OR "Grade C periodontitis" OR "Periodontal Bone Losses" OR "Periodontal Bone Loss" OR "Osteoporosis" OR "Osteoporoses" OR "Post-Traumatic Osteoporoses" OR "Post-Traumatic Osteoporosis" OR "Senile

	Osteoporoses" OR "Senile Osteoporosis" OR "Age-Related Bone Loss" OR "Age-Related Bone Losses" OR "Age-Related Osteoporosis" OR "Age Related Osteoporosis" OR "Age-Related Osteoporoses" OR "Periapical Disease" OR "Periapical Diseases" OR "Furcation Defects" OR "Furcation Defect" OR "Alveolar Resorption" OR "Alveolar Resorptions" OR "Alveolar bone resorption" OR "Alveolar bone resorptions" OR "Osteoarthritis" OR "Osteoarthritides" OR "Osteoarthrosis" OR "Osteoarthroses" OR "Degenerative Arthritides" OR "Degenerative Arthritis" OR "Arthrosis" OR "Arthroses" OR "Osteoarthrosis Deformans") AND ("Jaws" OR "Jaw" OR "Jawbones" OR "Jawbone" OR "Mandibles" OR "Mandible" OR "Mandibular bone" OR "Mandibular bones" OR "Dentomaxillofacial" OR "Dento-maxillo-facial" OR "Dento maxillo facial" OR "Maxillofacial" OR "Maxillo-facial" OR "Maxillas" OR "Maxilla" OR "Mandibular bony structures" OR "Mandibular bony structure" OR "Maxillary Bone" OR "Maxillary Bones" OR "Maxillae" OR "Facial Bone" OR "Facial Bones" OR "Alveolar Bone Losses" OR "Alveolar Bone Loss" OR "Alveolar bone" OR "Alveolar bones" OR "Furcal" OR "Periapical" OR "Periapex") AND ("Radiomics" OR "Radiomics technique" OR "Radiomic" OR "Texture Analysis" OR "Texture Analysis (TA)" OR "Radiomic Machine Learning" OR "feature extraction") AND (LIMIT-TO (DOCTYPE , "ar")) View less
Web of Science (Jan 12, 2022)	(((AB=("Dental Radiography" OR "facial scanning" OR "Intraoral radiography" OR "Intra-oral radiography" OR "Intra oral radiography" OR "Intraoral imaging" OR "Intra-oral imaging" OR "Intra oral imaging" OR "intraoral scanning" OR "Periapical radiography" OR "Periapical imaging" OR "Extraoral radiography" OR "Extra-oral radiography" OR "Extra oral radiography" OR "Extraoral imaging" OR "Extra-oral imaging" OR "Extra oral imaging" OR "Bitewing Radiography" OR "Bitewing Radiographies" OR "Dental Digital Radiography" OR "Dental panoramic radiographs" OR "Dental panoramic radiograph" OR "Pantomography" OR "Pantomographies" OR "Orthopantomography" OR "Orthopantomographies" OR "Panoramic Radiography" OR "Panoramic Radiographies" OR "Cone Beam Computed Tomography" OR "Cone-beam computed tomography (CBCT)" OR CBCT OR "CBCT scans" OR "Cone-Beam CT Scan" OR "Cone-Beam CT Scans" OR "Volume Computed Tomography" OR "Volumetric CT" OR "Volumetric Computed Tomography" OR "Cone-Beam CAT Scan" OR "Cone-Beam CAT Scans" OR "Cone-Beam Computer-Assisted Tomography" OR "Cone Beam Computer Assisted Tomography" OR "Cone-Beam Computerized Tomography" OR "Cone Beam Computerized Tomography" OR "Cone-Beam CT" OR "Cone Beam CT" OR "Volume CT" OR "NMR Imaging" OR "MR Tomography" OR "NMR Tomography" OR "Steady-State Free Precession MRI" OR "Steady State Free Precession MRI" OR "Zeugmatography" OR "Magnetic Resonance Image" OR "Magnetic Resonance Images" OR "Magnetization Transfer Contrast Imaging" OR "MRI Scans" OR "MRI Scan" OR "Proton Spin Tomography" OR "fMRI" OR "Functional MRI" OR "Functional MRIs" OR "Functional Magnetic Resonance Imaging" OR "Spin Echo Imaging" OR "Spin Echo Imagings" OR "PET-CT Scan" OR "PET-CT Scans" OR "PET CT Scan" OR "PET CT Scans" OR "CT PET" OR "Positron Emission Tomography-Computed Tomography" OR "PET-CT" OR "CT PET Scan" OR "CT PET Scans" OR "Radioisotope Scanning" OR Scintigraphy OR "Gamma Camera Imaging" OR Scintiphotography OR "SPECT CT" OR "CT SPECT Scan" OR "CT SPECT Scans" OR "CT SPECT" OR "CT

	SPECTs" OR "SPECT CT Scan" OR "SPECT CT Scans" OR "Multisection Computed Tomography" OR "Dual-energy CT" OR "Multidetector row CT" OR "Perfusion CT" OR "Multislice Computed Tomography" OR "Multidetector-Row Computed Tomography" OR "Multidetector Row Computed Tomography" OR "Diagnostic imaging" OR "Medical Imaging")) AND AB=("Bone Neoplasm" OR "Bone Cancer" OR "Cancer of the Bone" OR "Cancer of Bone" OR "Bone Lesion" OR "Bone Lesions" OR "osseous pathology" OR "bone pathology" OR "osseous pathologies" OR "bone pathologies" OR "Osseous Lesion" OR "Osseous Lesions" OR "Cyst" OR "cysts" OR "Tumor" OR "Neoplasm" OR "Tumors" OR "Neoplasia" OR "Neoplasias" OR "Cancer" OR "Cancers" OR "Malignant Neoplasm" OR "Malignancy" OR "Malignancies" OR "Malignant Neoplasms" OR "Benign Neoplasms" OR "Benign Neoplasm" OR "fibro-osseous lesions" OR "fibro-osseous lesions" OR "fibroosseous lesions" OR "fibroosseous lesion" OR "Inflammatory lesions" OR "Inflammatory lesion" OR "Giant Cell Tumor of Bone" OR "Familial Fibrous Dysplasia of Jaw" OR "Familial Multilocular Cystic Disease of the Jaws" OR "Familial Benign Giant-Cell Tumor of the Jaw" OR "Osteomyelitis" OR "Osteonecroses" OR "Osteonecrosis" OR "Bone Necrosis" OR "Bone Necroses" OR "Avascular Necrosis of Bone" OR "Bone Avascular Necrosis" OR "Aseptic Necrosis of Bone" OR "Bone Aseptic Necrosis" OR "Bisphosphonate Associated Osteonecrosis of the Jaw" OR "Bisphosphonate-Induced Osteonecrosis of the Jaw" OR "Bisphosphonate Induced Osteonecrosis of the Jaw" OR "Bisphosphonate-Induced Osteonecrosis of the Jaws" OR "Bisphosphonate Induced Osteonecrosis of the Jaws" OR "Bisphosphonate-Related Osteonecrosis of the Jaw" OR "Bisphosphonate Related Osteonecrosis of the Jaw" OR "Bisphosphonate-Associated Osteonecrosis of the Jaws" OR "Bisphosphonate Associated Osteonecrosis of the Jaws" OR "Bisphosphonate-Associated Osteonecrosis" OR "Bisphosphonate Associated Osteonecrosis" OR "Bisphosphonate-Associated Osteonecroses" OR "Bisphosphonate Osteonecrosis" OR "Bisphosphonate Osteonecroses" OR "Osteosarcomas" OR "Osteosarcoma Tumor" OR "Osteosarcoma Tumors" OR "Osteogenic Sarcomas" OR "Osteogenic Sarcoma" OR "Ewing Sarcoma" OR "Sarcoma Ewing" OR "Osteoblastomas" OR "Giant Osteoid Osteoma" OR "Giant Osteoid Osteomas" OR "Osteoid Osteomas" OR "Osteoid Osteoma" OR "Osteochondromas" OR "Osteocartilaginous Exostoses" OR "Osteocartilaginous Exostosis" OR "Chondrosteoma" OR "Chondrosteomas" OR "Giant Cell Tumor of Bone" OR "Bone Fibrous Dysplasia" OR "Bone Fibrous Dysplasias" OR "Fibrocystic Dysplasia of Bone" OR "Bone Fibrocystic Dysplasia" OR "Bone Fibrocystic Dysplasias" OR "Fibrocartilaginous Dysplasia of Bone" OR "Bone Fibrocartilaginous Dysplasia" OR "Bone Fibrocartilaginous Dysplasias" OR "Bone Dysplasias" OR "Bone Dysplasia" OR "Ossifying Fibroma" OR "Ossifying Fibromas" OR "Furcal Lesion" OR "Furcal lesions" OR "Periodontal disease" OR "Periodontal diesases" OR "Periodontitis" OR "Aggressive Periodontitis" OR "Periodontitis grade C" OR "Grade C periodontitis" OR "Periodontal Bone Losses" OR "Periodontal Bone Loss" OR "Osteoporosis" OR "Osteoporoses" OR "Post-Traumatic Osteoporoses" OR "Post-Traumatic Osteoporosis" OR "Senile Osteoporoses" OR "Senile Osteoporosis" OR "Age-Related Bone Loss" OR "Age-Related Bone Losses" OR "Age-Related Osteoporosis" OR "Age Related Osteoporosis" OR "Age-Related Osteoporoses" OR "Periapical Disease" OR "Periapical Diseases" OR "Furcation Defects" OR "Furcation Defect" OR "Alveolar Resorption" OR "Alveolar Resorptions" OR "Alveolar bone resorption" OR "Alveolar bone resorptions" OR "Osteoarthritis" OR "Osteoarthritides" OR "Osteoarthrosis" OR "Osteoarthroses" OR "Degenerative Arthritides" OR "Degenerative Arthritis" OR "Arthrosis" OR "Arthroses" OR "Osteoarthrosis Deformans")) AND AB=("Jaws" OR "Jaw" OR "Jawbones" OR "Jawbone" OR "Mandibles" OR "Mandible" OR "Mandibular bone" OR "Mandibular bones" OR "Dentomaxillofacial" OR "Dento-maxillo-facial" OR "Dento maxillo facial" OR "Maxillofacial" OR "Maxillo-facial" OR "Maxillas" OR "Maxilla" OR "Mandibular bony structures" OR "Mandibular bony structure" OR "Maxillary Bone" OR "Maxillary Bones" OR "Maxillae" OR "Facial Bone" OR "Facial Bones" OR "Alveolar Bone Losses" OR "Alveolar Bone Loss" OR "Alveolar bone" OR "Alveolar bones" OR "Furcal" OR "Periapical" OR "Periapex")) AND AB=("Radiomics" OR "Radiomics technique" OR "Radiomic" OR "Texture Analysis" OR "Texture Analysis (TA)" OR "Radiomic Machine Learning" OR "feature extraction")
Science Direct (Jan 12, 2022)	("imaging" OR "radiology") AND ("bone lesion" OR "osseous pathology") AND ("jaw" OR "mandible") AND ("radiomics" OR "texture analysis")

Google Scholar (Sep 12, 2021)	("imaging" OR "radiology") AND ("bone lesion" OR "osseous pathology") AND ("jaw" OR "mandible") AND ("radiomics" OR "texture analysis")
JSTOR (Jan 12, 2022)	("imaging" OR "radiology") AND ("bone lesion" OR "osseous pathology") AND ("jaw" OR "mandible") AND ("radiomics" OR "texture analysis")
ProQuest (Jan 12, 2022)	("imaging" OR "radiology") AND ("bone lesion" OR "osseous pathology") AND ("jaw" OR "mandible") AND ("radiomics" OR "texture analysis")

Supplementary Material 2. Excluded articles and reason for exclusion. (n=43).

Author, year (Databases)	Reason for exclusion
Abdolali et al. (2019)[1]	1
Aliaga et al. (2020)[2]	1
Apolinário et al. (2016)[3]	1
Araújo et al. (2021)[4]	1
Arsan et al. (2017)[5]	1
Astuti et al. (2017)[6]	1
Bhandari et al. (2020)[7]	1
Birdal et al. (2016)[8]	1
Buhari et al. (2020)[9]	1
Chen et al. (2021)[10]	1
Cordeiro et al. (2016)[11]	7
Kauke et al. (2019)[12]	1
Kavitha et al. (2012)[13]	2
Kavitha et al. (2013)[14]	2
Kavitha et al. (2016)[15]	1
Kwon et al. (2020)[16]	1
Li et al. (2021)[17]	1
Lin et al. (2017)[18]	1
Liu et al. (2021)[19]	1
Mol et al. (1992)[20]	2
Mol et al. (1992)[21]	2
Muramatsu et al. (2016)[22]	9
Naik et al. (2016)[23]	1
Obuchowicz et al. (2019)[24]	7
Rosa (2019)[25]	3
Shrout et al. (1998)[26]	2

Sindeaux et al. (2014)[27]	1
Southard et al. (1996)[28]	4
Taguchi et al. (1996)[29]	1
Tosun et al. (2021)[30]	1
Veena et al. (2017)[31]	8
Vigil et al. (2021)[32]	5
Yu et al. (2021)[33]	6
Wang et al. (2016)[34]	5
Wang et al. (2021)[35]	1

Author, year (Gray Literature)	**Reason for exclusion**
Ariji et al. (2011)[36]	1
Horiba et al. (2015)[37]	1
Hua et al. (2019)[38]	4
Iwaszenko et al. (2021)[39]	1
Jin et al. (1999)[40]	2
Lee et al. (2018)[41]	1
Lin et al. (2015)[42]	1
Reddy et al. (2010)[43]	7

1. No radiomics analysis; 2. Scanned radiographs; 3. Thesis from an included article; 4. Non-human studies; 5. No bone disease; 6. The article considers included and excluded diseases together for statistical analysis; 7. The author only differentiates pathological from health areas; 8. Conference paper; 9. Testing cases not based in conventional imaging exams.

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Supplementary Material 3 - Methodological quality assessment for Cross-Sectional Studies (n=23)

	Abdolali et al., 2016	Alzubaidi & Otoom, 2020	Bianchi et al., 2020 (1)	Bianchi et al., 2020 (2)	De Rosa et al., 2020	Gonçalves et al., 2020	Haghnegahdar et al., 2016	Hwang et al., 2017	Ito et al., 2021 (1)	Ito et al., 2021 (2)	Jiang et al., 2021	Kavitha et al., 2014	Kawashima et al., 2019	Marar et al., 2020	Muraoka et al., 2022	Nurtanio et al., 2013	Oda et al., 2019	Okada et al., 2015	Orhan et al., 2021	Pociask et al., 2021	Roberts et al., 2013	Sela & Widyaningrum, 2015	Yilmaz et al., 2017
1	N	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	N	Y	N	Y	N	Y	N	N	N	N
2	N	N	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	Y	Y	Y	Y	N
3	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N
4	N	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N
5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6	N	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	N	Y	N	Y	N	Y	N	N
7	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
8	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	mod	mod	high	high	high	high	low	high	high	high	high	mod	high	mod	high	mod	high	mod	high	mod	high	mod	low

1. Were the criteria for inclusion in the sample clearly defined?; 2. Were the study subjects and the setting described in detail?; 3. Was the exposure measured in a valid and reliable way?; 4. Were objective, standard criteria used for measurement of the condition?; 5. Were confounding factors identified?; 6. Were strategies to deal with confounding factors stated?; 7. Were the outcomes measured in a valid and reliable way?; 8. Was appropriate statistical analysis used? Y=Yes; N= No; U= Unclear; NA = Not Applicable. Low quality: one to three "yes" answers; moderate quality: four to six "yes" answers or high quality: seven or eight "yes" answers.

CAPÍTULO 6

DENTECH: A MOBILE APPLICATION FOR REMOTE CARE AND TEACHING IN DENTISTRY

Título: Dentech: Um aplicativo de celular para assistência à saúde e ensino em Odontologia de forma remota

Glaucia Nize Martins Santos
ORCID: https://orcid.org/0000-0002-9955-4323
Universidade de Brasília, Brasil
E-mail: nize.gal@gmail.com

Helbert Eustáquio Cardoso da Silva
ORCID: https://orcid.org/0000-0003-2662-6987
Universidade de Brasília, Brasil
E-mail: helbertcardososilva@gmail.com

João Pedro Mota Jardim
ORCID: https://orcid.org/0009-0002-4276-1521
Universidade de Brasília, Brasil
E-mail: jpmota.unb@gmail.com

Vandor Roberto Vilardi Rissoli
ORCID: https://orcid.org/0009-0000-2824-3395
Universidade de Brasília, Brasil
E-mail: vandorissoli@gmail.com

André Ferreira Leite
ORCID: https://orcid.org/0000-0002-7803-4740
Universidade de Brasília, Brasil
E-mail: andreleite@unb.br

Nilce Santos de Melo
ORCID: https://orcid.org/0000-0001-7268-485X
Universidade de Brasília, Brasil
E-mail: nilce@unb.br

ABSTRACT

OBJECTIVE: to create a complementary digital tool for remote health care and teaching in Dentistry. METHOD: a mobile application prototype combining m-health and m-learning was developed, using free resources. RESULT: the prototype has three different profiles related to

oral health: Dentist, Professor Dentist and Student. With the prototype, it is possible for the Dentist to exchange information with patients via Whatsapp and save information in electronic medical records. Also, the prototype allows the Professor Dentist to develop clinical scenarios, make them available for assistance simulations to the Student profile, and evaluate the resulting interactions later. CONCLUSION: technology is an important part of our daily lives and improves information and communication. Despite the advantages, its use is still challenging due to limited technological knowledge, in addition to the precariousness of the Internet connection in a general way.
Keywords: Teledentistry; Dentistry Education; Mobile Application; Simulation Training; Remote Learning.

RESUMO

OBJETIVO: criar uma ferramenta digital complementar para assistência remota em saúde e para o ensino em Odontologia. MÉTODO: um protótipo de aplicativo de celular combinando o *m-health* e o *m-learning* foi elaborado, utilizando recursos gratuitos. RESULTADOS: o protótipo dispõe de três perfis diferentes envolvidos com a saúde bucal: Clínico Dentista, Professor Dentista e Estudante. Com o protótipo, é possível que o Clínico Dentista troque informações com pacientes via Whatsapp e registre informações em prontuários eletrônicos. Ainda, o protótipo permite que o Professor Dentista elabore casos clínicos e os disponibilize para simulações de atendimentos ao perfil Estudante, podendo avaliar as interações posteriormente. CONCLUSÃO: a tecnologia permeia o nosso cotidiano e possibilita maior amplitude de informação e comunicação. Apesar das vantagens, o seu uso ainda é desafiador, devido ao conhecimento tecnológico limitado, além da precariedade da conexão à Internet de forma ampla.
Palavras-chave: Teleodontologia; Educação em Odontologia; Aplicativos Móveis; Treinamento por Simulação; Ensino Remoto.

INTRODUÇÃO

Em decorrência das medidas restritivas impostas pela pandemia de COVID-19, o desenvolvimento de soluções inovadoras para otimizar a assistência à saúde e o ensino se acelerou (KRAEMER et al., 2020). Um exemplo é uso da tecnologia da informação e comunicação (TIC) para assistência e ensino em saúde, que pode ser referida como *e-saúde*, telessaúde ou telemedicina. Apesar de tais termos poderem ser usados como sinônimos, a telessaúde se refere a serviços clínicos e não clínicos, incluindo educação continuada para profissionais de saúde, enquanto a telemedicina se refere ao uso exclusivo no atendimento aos pacientes (EYSENBACH, 2001).

Ressalta-se que o uso de telefones celulares tem aumentado em todo o mundo, e que o aproveitamento dessa tecnologia na área da saúde é capaz e aumentar a acessibilidade aos cuidados assistenciais. Dessa forma, *mobile-health* ou *m-health* pode ser definido como a prestação de serviços de saúde por meio de ferramentas baseadas em chamadas telefônicas, consultas por vídeo ou trocas de mensagens de texto via dispositivos móveis, removendo barreiras geográficas, temporais, culturais e sociais (KAY; SANTOS; TAKANE, 2011).

Na Odontologia se intensificou o uso da teleodontologia para o diagnóstico, monitoramento, prescrição e rastreamento de doenças. Sua incorporação à prática de rotina permitiu uma ampla gama de aplicações, como a triagem remota de pacientes e a consequente redução de atendimentos em consultórios e hospitais já sobrecarregados (GHAI, 2020). Dessa forma, a teleodontologia não só ampliou o atendimento odontológico, como também possibilitou o seu gerenciamento parcial ou total a quilômetros de distância de profissionais capacitados.

O ensino emergencial remoto, uma solução baseada em *e-learning* (aprendizado que acontece via meios eletrônicos), surgiu como estratégia didática e pedagógica para diminuir os impactos do isolamento social, a fim de garantir a continuidade dos semestres letivos (IYER; AZIZ; OJCIUS, 2020; SANTOS et al., 2021). No cenário educacional, aprender com o uso de tecnologias em celulares é um tipo de *e-learning* e pode ser definido como "aprendizagem móvel" (*mobile-learning* ou *m-learning*) (SHARPLES, 2013). Trata-se de uma metodologia de aprendizagem que utiliza *smartphones*, *tablets* e outros recursos tecnológicos que propiciam interações, treinamentos e capacitações diversas, podendo ser baseada totalmente em dispositivos móveis, quanto apenas utilizá-los em atividades complementares (SHARPLES, 2013).

Considerando os benefícios obtidos com a teleodontologia e com o *e-learning* durante a pandemia, o presente trabalho teve como objetivo descrever o protótipo de um novo aplicativo móvel indicado tanto para o atendimento remoto de pacientes, como também para o apoio ao ensino de graduação em Odontologia.

MÉTODO

DENTECH: Proposta de aplicativo móvel

Este trabalho propõe o desenvolvimento de um aplicativo móvel voltado para a assistência odontológica de pacientes de forma remota. A partir dessa tecnologia, os cirurgiões-dentistas poderiam realizar o monitoramento de pacientes, proporcionando orientações sobre seu estado de saúde, disponibilizando prescrições, laudos e atestados médicos, exames de imagem e laboratoriais, além de otimizar consultas presenciais quando necessário. Esta ferramenta beneficiaria pacientes acamados, portadores de deficiências, pacientes imunodeprimidos e/ou em tratamento quimioterápico/ radioterápico. Além disso, favoreceria o acesso ao cuidado odontológico de populações específicas como a população carcerária, população indígena, populações ribeirinhas e rurais em geral.

Ademais, o mesmo aplicativo móvel poderia ser utilizado como ferramenta pedagógica para auxiliar o atendimento clínico de estudantes de Odontologia por meio da simulação de pacientes, via conversas automatizadas empregando recursos provenientes da Inteligência Artificial, como *chatbots*, com o intuito de colaborar na melhoria das habilidades dos estudantes para se chegar a um diagnóstico, prescrever medicamentos, solicitar exames de imagem e laboratoriais corretamente, além de fornecer orientações adequadas a cada caso clínico. A simulação de atendimento clínico poderia reduzir a ansiedade dos aprendizes ao conduzir uma conversa formal com o paciente e auxiliar na tomada de decisões.

RESULTADO

DENTECH: Desenvolvimento do protótipo

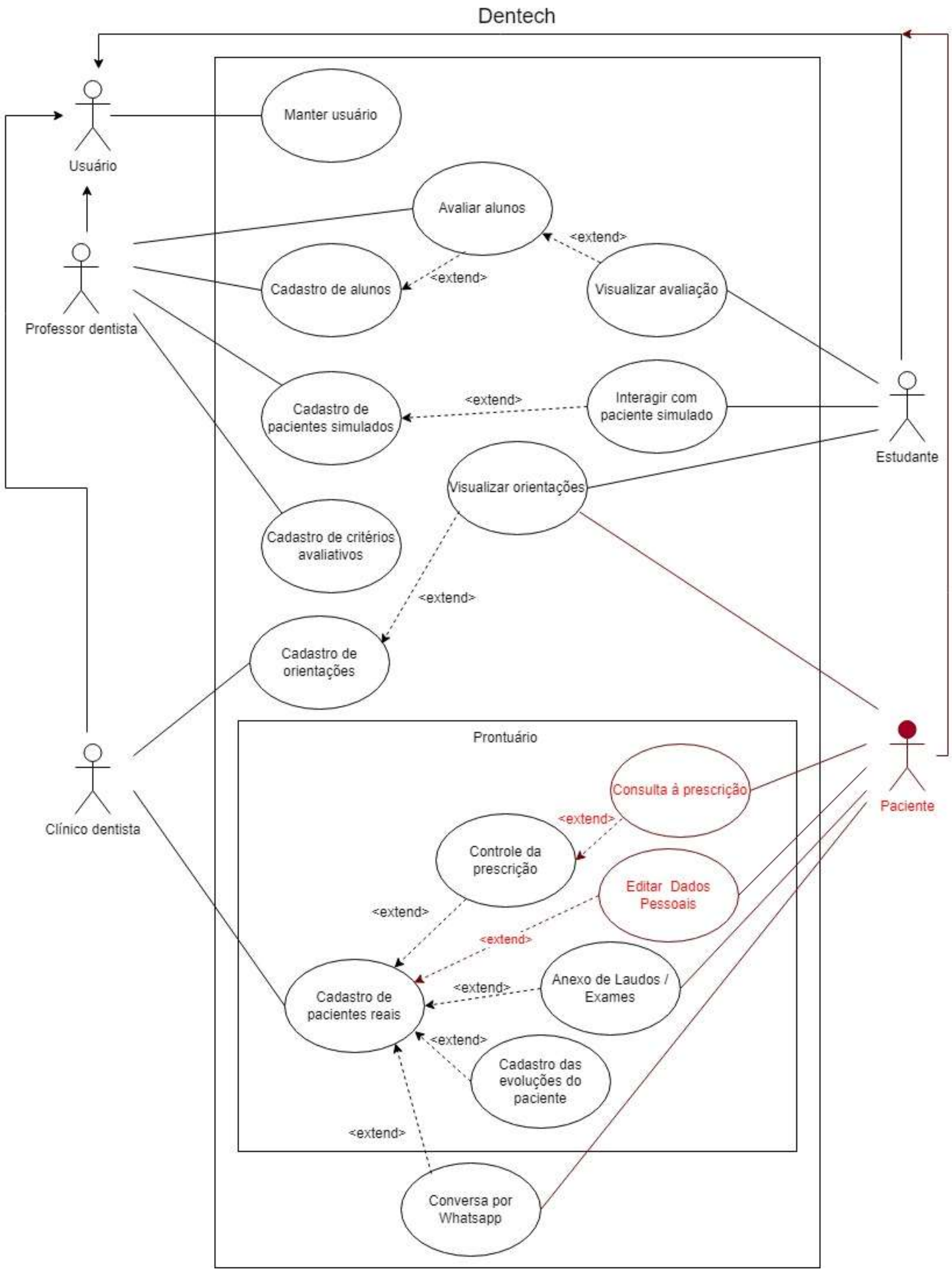
Após a concepção da ideia do aplicativo móvel, seu protótipo foi desenvolvido por uma cooperação entre a equipe de Engenharia de Software e o Departamento de Odontologia da Universidade de Brasília. O protótipo foi elaborado usando os recursos gratuitos fornecidos pelo ambiente do Oracle Application Express (Oracle Apex®). Esse ambiente é uma plataforma de desenvolvimento extensível e de codificação (*low-code*) que roda como parte do Oracle Database e permite a construção de aplicações seguras com recursos de classes (*word-class*) na linguagem PL/SQL.

Para a confecção do protótipo funcional do aplicativo foi utilizada uma metodologia bastante adotada entre os desenvolvedores de software, chamada de Metodologia Ágil. Com o objetivo de proporcionar maior entrega de valor em um menor intervalo de tempo, esta metodologia prevê encontros periódicos para a definição das atividades da semana, chamadas de *Sprints*. Assim, a cada interação era apresentada uma nova funcionalidade, que era então validada pelos autores no papel de usuários do produto a ser desenvolvido.

O protótipo foi inicialmente elaborado contemplando aspectos fundamentais de segurança, exigindo a conexão com autenticação de seus usuários (processo de conexão ou *login*), além de outras funcionalidades importantes aos objetivos do DENTECH.

Para um melhor entendimento das funcionalidades previstas no projeto foi elaborado o Diagrama de Casos de Uso, utilizado no desenvolvimento de software para listar os chamados atores (usuário ou equipamento que interage com o aplicativo) e seus casos de uso (funcionalidades do sistema), apresentados na Figura 1. O ator e os casos de uso apresentados em vermelho representam o perfil paciente, que não foi implementado no protótipo por não possuir uma funcionalidade única, sendo dispensado nessa fase inicial de validação do protótipo.

Figura 1 – Diagrama de Casos de Uso do DENTECH.



Fonte: Santos et al. (2023)

Módulo de Conexão (*login*)

Esse protótipo é composto por três perfis de usuários (atores) que possuem ambientes interativos específicos na aplicação (perfis): perfil do Clínico Dentista, perfil do Professor Dentista e perfil do Estudante. Todos os perfis ou tipos de usuários acessam o aplicativo móvel usando seu próprio identificador e senha pessoal.

Para o Clínico Dentista foi desenvolvido um ambiente virtual, a partir do módulo de conexão (*login*), o qual permite que ele monitore e acompanhe remotamente pacientes reais cadastrados. Para o Professor Dentista foi desenvolvido um ambiente virtual de ensino, também a partir do módulo de conexão. O terceiro ator, o Estudante, tem acesso ao ambiente de ensino com material instrucional criado pelo Professor Dentista. O perfil Paciente, ainda não desenvolvido, também faria uso do módulo de conexão para entrada no seu ambiente virtual, o qual permitiria troca de informações com o Profissional Dentista e o armazenamento de dados pessoais e exames.

A Figura 2 apresenta a primeira janela interativa do protótipo que solicita a identificação de qualquer tipo de usuário, por meio do fornecimento de sua identificação (Nome do Usuário) e senha para a realização da conexão mais segura pelo processo de autenticação do aplicativo.

Figura 2 – Janela de conexão para qualquer perfil de usuário.

Fonte: Santos et al. (2023)

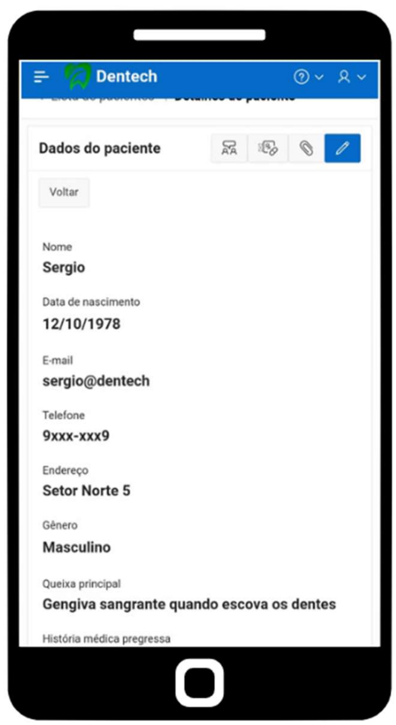
Perfil do Clínico Dentista

a. Módulo de Prontuário Odontológico

Este módulo funciona similarmente a um prontuário físico, no qual a lista de prontuários digitais dos pacientes está organizada por ordem alfabética, a fim de facilitar o seu acesso e se tornar um recurso único para cada paciente. A busca por determinado prontuário pode ser realizada digitando qualquer termo relacionado ao paciente na barra de pesquisa. Essa ferramenta pode auxiliar no levantamento do perfil epidemiológico dos pacientes cadastrados, por meio da pesquisa por idade, comorbidades ou outros parâmetros de interesse.

Neste módulo, o clínico dentista pode acessar, registrar e editar as informações pessoais e de saúde de cada paciente durante os atendimentos, com cada evolução separada por data e assinada eletronicamente. Ainda, podem ser salvos em anexo exames por imagem em formato JPG (*Joint Photographic Experts Group*). Prescrições, orientações, laudos e atestados gerados pelo profissional ficam vinculados ao prontuário do paciente atendido, para acesso quando necessário. A Figura 3 mostra parte da janela interativa de registro dos dados de cada paciente no atual protótipo do aplicativo.

Figura 3 – Janela de cadastro e atualização dos dados do paciente.



Fonte: Santos et al. (2023)

b. Módulo de Prescrição

Neste módulo, o Clínico Dentista pode gerar formulários padronizados e com cabeçalhos pré-preenchidos, nos quais constem prescrição de medicamentos, orientações pré e pós-procedimentos, instruções, solicitação de exames, atestados, laudos e relatórios, assiná-los digitalmente, salvá-los em formato PDF (*Portable Document Format*) e distribuí-los aos pacientes ou a outros interessados via e-mail. Uma vez enviados, os documentos não podem mais ser editados. A Figura 4 apresenta uma nova janela interativa ilustrando a apresentação de um documento virtual de prescrição fornecido pelo perfil Clínico Dentista, que poderá ser enviado para o paciente.

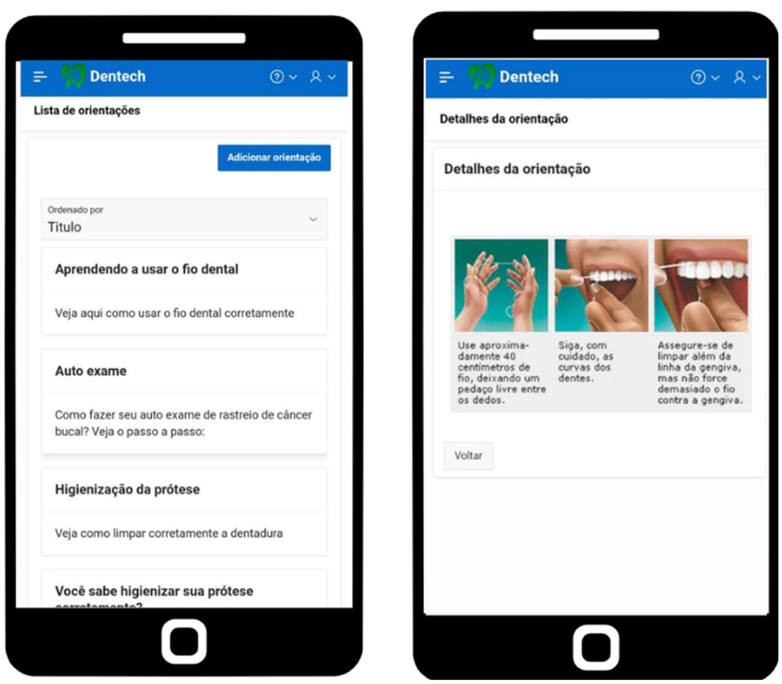
Figura 4 – Nova janela da aplicação que apresenta uma prescrição odontológica com assinatura do Clínico Dentista.

Fonte: Santos et al. (2023)

c. Módulo de Orientações

Este módulo tem como finalidade apresentar conteúdo de educação em saúde bucal e é composto por orientações gerais, isto é, não personalizadas, desenvolvidas pelo perfil Clínico Dentista, direcionadas a todos os pacientes. Este perfil é o único que pode criar, editar ou excluir as orientações, que podem conter texto e imagem, conforme a necessidade. São exemplos de orientações gerais os cuidados com a higiene bucal, as recomendações após realização de cirurgias dentárias e o autoexame para rastreio de câncer bucal. A Figura 5 apresenta duas janelas com dados de orientações que podem ser elaboradas quando o clínico dentista acreditar ser mais relevantes para compreensão de seus pacientes.

Figura 5 – Janelas de orientação que o paciente poderá consultar continuamente, podendo o dentista detalhar com ilustrações instrutivas quando achar necessário.



Fonte: Santos et al. (2023)

d. Módulo de Comunicação

O perfil do Clínico Dentista apresenta possibilidade de interação síncrona ou assíncrona com o paciente, por meio de uma sala de conversa via WhatsApp, disponível para troca de mensagens de texto, fotos, documentos e áudios, sempre que necessário. O uso dessa ferramenta facilita a comunicação à distância e dá a oportunidade de tirar dúvidas, orientar, prescrever medicamentos, solicitar exames e sugerir hipóteses diagnósticas de forma mais célere. Cabe salientar que será necessário a criação de um sistema de validação de imagens, via *token* ou via chave personalizada, de forma a garantir a segurança e veracidade dos dados enviados pelo WhatsApp.

Perfil Professor Dentista

a. Módulo de Prontuário Odontológico Simulado

Utilizando o mesmo padrão de desenvolvimento de prontuários citado acima, o perfil Professor Dentista pode criar prontuários de pacientes simulados, adequados aos temas recém estudados pelos estudantes, nos quais podem constar imagens, evoluções e prescrições. Neste módulo, os critérios avaliativos personalizados podem ser cadastrados pelo perfil Professor Dentista. Tais critérios são também independentes, sendo que não há restrição de quantidade a serem criados. Dessa forma, para cada prontuário de pacientes simulados, o professor pode selecionar os critérios avaliativos mais úteis dentre aqueles pré-cadastrados e dar uma ponderação na nota de cada critério.

b. Módulo de Estudantes Cadastrados

Neste módulo, o perfil Professor Dentista cadastra cada um de seus estudantes. Ao selecionar um aluno cadastrado, o professor é capaz de verificar com quais pacientes fictícios o estudante interagiu. Ao acessar cada interação, o professor pode averiguar as informações acrescentadas pelos alunos ao prontuário após o atendimento simulado e então avaliar o desempenho deles na condução do caso clínico, utilizando os critérios avaliativos previamente cadastrados.

Perfil do Estudante

a. Módulo de Prontuário Odontológico Simulado

Ao se conectar a aplicação, o perfil do Estudante tem acesso aos prontuários produzidos, como material instrucional, pelo perfil do Professor Dentista. Nesses prontuários, o estudante pode ver o histórico do paciente simulado e acrescentar informações coletadas após o atendimento no campo evolução. Todas as informações geradas no atendimento ao paciente simulado ficam salvas no prontuário, para que sejam avaliadas posteriormente pelo professor quanto à habilidade do estudante em gerenciar a conduta clínica referente ao caso apresentado. A avaliação realizada pelo professor acontece por meio dos critérios avaliativos e comentários ao caso, ficando disponível imediatamente ao estudante. O rápido *feedback* e a avaliação personalizada permitem que o estudante compreenda melhor suas dificuldades e direcione seus estudos focando nos assuntos de mais necessidade de melhoria na aprendizagem, assim como de seu maior interesse.

b. Módulo de Prescrição

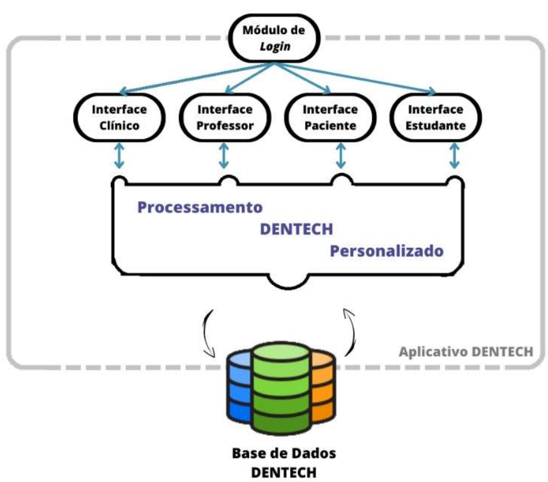
É recomendado que, após a interação com o paciente simulado, o estudante desenvolva uma conduta frente à queixa principal, considerando o histórico do paciente no prontuário fictício. Para tanto, o módulo prescrição permite que o estudante gere atestados, prescrições, solicitações de exames e orientações personalizadas. Porém, não há possibilidade de assinatura eletrônica, para que os documentos não tenham validade legal. Todos os documentos gerados ficam salvos no prontuário do respectivo paciente fictício.

c. Módulo de Comunicação

Esse módulo permitirá o uso do WhatsApp para conversar com pacientes fictícios, por meio de recursos provenientes da área de Inteligência Artificial, mais conhecidos como *chatbot*, capazes de simular a interação conversacional que geralmente acontece em uma consulta real. Como trabalhos futuros, se propõe aprimorar o Módulo de Comunicação específico para o estudante, a ser personalizado pelo professor.

A Figura 6 apresenta um esquema ilustrativo do funcionamento do aplicativo DENTECH que a partir da conexão autorizada (Módulo de conexão - *login*) associa os módulos correspondentes ao perfil de usuário que estará usando o aplicativo. Todos os recursos oferecidos pelo aplicativo estarão disponíveis de maneira personalizada ao usuário conectado para o processamento desejado à assistência, o acompanhamento ou ao ensino ofertado pelo aplicativo no momento. A base de dados projetada para o DENTECH estará armazenada no Sistema Gerenciador de Banco de Dados (SGBD) responsável pela segurança e fornecimento dos dados e informações somente para os usuários cadastrados no DENTECH.

Figura 6 – Esquema ilustrativo do funcionamento do aplicativo DENTECH.



Fonte: Santos et al. (2023)

IMPLICAÇÕES DE CUSTO

O protótipo DENTECH foi construído em uma plataforma de código aberto para reduzir o custo e pode ser usado em todo o mundo. No entanto, os objetivos do protótipo eram educacionais e torná-lo uma ferramenta comercial envolve outros aspectos legais no uso de tal ambiente, além das limitações dos recursos tecnológicos que são oferecidos por este ambiente (Oracle Apex®) de forma gratuita não serem suficientes para uma escala comercial.

Para transformar a aplicação em escala comercial, deve-se adquirir uma licença da empresa fornecedora (Oracle), ou recriá-la com tecnologias de código aberto para a parte visual (como React Native), em conjunto com algum SGBD, a fim de armazenar os dados e as informações manipuladas pela aplicação, além de uma API (*Application Programming Interface* ou, em português, Interface de Programação de Aplicação) que seja adequada para estabelecer a comunicação entre a aplicação e o SGBD.

Para a publicação e disponibilização da aplicação em dispositivos Android (Play Store) é necessário possuir uma conta de desenvolvedor, que atualmente custa 25 dólares, pago uma única vez. Já para dispositivos iOS (Apple Store), além de possuir uma conta de desenvolvedor, são pagos 99 dólares anuais.

Já para o armazenamento dos dados, a maneira mais comum seria através de um provedor de nuvem como Amazon Web Services, Google Cloud ou Microsoft Azure, cujo os valores dependem da demanda solicitada para o provedor de interesse.

PRIVACIDADE

Existem alguns riscos que devem ser considerados ao lidar com tecnologia, principalmente no que diz respeito à proteção de dados pessoais. Muitos métodos de segurança devem ser adotados, incluindo assinatura digital, palavras-chave, criptografia, entre outros

(ANDRADE et al., 2014). Os dados pessoais partilhados pelo usuário devem ser acessíveis apenas aos profissionais de saúde. Os detalhes de contato, como nome e número do celular, seriam usados para rastreamento de contato. A maior parte dos dados que seriam coletados pelo aplicativo seriam armazenados no Oracle Apex® e estariam disponíveis apenas para a equipe de suporte técnico e os profissionais de saúde. As restrições de criptografia de fotos e imagens para o acesso de pessoas aos *smartphones* e a contagem de aplicativos corporativos seriam utilizadas para aumentar a segurança no intercâmbio de dados, respeitando a legislação que trata da garantia da privacidade dos dados.

DISCUSSÃO

Este trabalho concebe a ideia de um aplicativo móvel com dois objetivos principais, sendo estes baseados nos benefícios da teleodontologia e do *e-learning*, principalmente após a pandemia da COVID-19. O primeiro se propõe a auxiliar os dentistas e seus pacientes na realização da assistência odontológica e/ou monitoramento remoto de manifestações bucais referentes a patologias ou tratamentos sistêmicos, enquanto o outro auxiliaria os professores ao criar simulações de cenários de atendimento, a fim de colaborar na formação dos estudantes acerca da condução dos casos clínicos.

Um estudo recente (DA SILVA et al., 2021) mostrou os benefícios do uso da teleodontologia por pacientes submetidos ao tratamento de câncer bucal e de cabeça e pescoço, durante a pandemia de COVID-19. A continuidade do atendimento odontológico, a redução de visitas de pacientes ao hospital, a redução do risco de infecção pelo coronavírus e a limitação de consultas presenciais para proteger os profissionais de saúde foram as vantagens que reforçaram o uso da teleodontologia. Ressalta-se que, para pacientes acamados ou que moram em áreas isoladas, um contato pessoal, ainda que remoto, pode influenciar positivamente no estado de bem-estar, na motivação e na sensação de segurança do paciente, principalmente em períodos de incerteza, melhorando sua qualidade de vida (KANATAS; ROGERS, 2020; CAPUTO et al., 2022). Uma revisão sistemática (DA SILVA et al., 2022) analisou o uso da telessaúde no acompanhamento de pacientes com câncer de cabeça e pescoço quanto ao tipo de aplicativo utilizado, adesão do usuário à tecnologia, satisfação e qualidade de vida, demonstrando que o monitoramento remoto e/ou autogerenciamento de sintomas por meio de aplicativos móveis era viável para a maioria dos pacientes, com graus satisfatórios de aceitabilidade, satisfação, usabilidade e adesão. Observando-se que a assistência remota ganhou força e significado durante a pandemia, no fim do ano de 2022 foi promulgada a Lei 14.510/22, que conceitua e autoriza a prática da telessaúde em todo o território nacional, garantindo o seu exercício a todo profissional de saúde (BRASIL, 2022).

No contexto educacional, evidências crescentes confirmam que o *e-learning* é tão eficaz quanto os métodos tradicionais de ensino (SANTOS et al., 2016, 2021; HUYNH, 2017). A aprendizagem por dispositivo móvel é um subtipo de *e-learning*, embora não haja um acordo entre os estudiosos sobre sua definição devido à mobilidade tanto da tecnologia quanto da própria aprendizagem (SÖNMEZ et al., 2018). Esta modalidade de ensino também permite que os professores personalizem a instrução com apoio tecnológico e que os estudantes autorregulem a sua própria aprendizagem (RISSOLI; FURTADO, 2019). Além disso, a aprendizagem móvel ajuda os estudantes a desenvolver habilidades tecnológicas e de conversação, a encontrar respostas para suas perguntas, a desenvolver um senso de colaboração ao permitir o compartilhamento de conhecimento e, assim, alavancar seus resultados de aprendizagem (NACIRI et al., 2020). Como os dispositivos móveis são inerentemente portáteis, pesquisadores observaram a exploração do uso da aprendizagem móvel em contextos além da sala de aula tradicional (SUNG; CHANG; LIU, 2016). Essa disponibilidade quase onipresente torna o uso da aprendizagem móvel em ambientes informais uma alternativa real para a assimilação dos estudantes (SANTOS et al., 2017; CROMPTON; BURKE, 2018).

Apesar das vantagens, o uso da tecnologia ainda é desafiador nos contextos da saúde e da educação. A falta de aceitação das ferramentas de teleodontologia por alguns profissionais de saúde pode ser atribuída à complexidade em lidar com novas tecnologias e sua resistência em adquirir novas habilidades. Uma avaliação imprecisa do caso, o aumento nos custos e o maior tempo dispensado para resolver as demandas dos pacientes são preocupações (ESTAI et al., 2016; DA SILVA et al., 2021). Existem também as limitações relacionadas aos pacientes, como incapacidade de conexão com o aplicativo, baixa destreza manual, pouca familiaridade com dispositivos móveis e pouco conhecimento em tecnologia (MAIR; WHITTEN, 2000).

Os problemas técnicos relacionados ao cenário educacional se assemelham com os de assistência remota e englobam o conhecimento tecnológico limitado e a falta de treinamento continuado dos docentes, a conexão ruim com a Internet nas universidades, o recurso financeiro insuficiente e as dificuldades para converter alguns tópicos para a versão remota (SANTOS et al., 2021). Existe ainda a necessidade de melhor investigar o tipo de pedagogia usada nas demandas de aprendizagem móvel em estudos futuros, considerando que os dispositivos móveis requerem um método pedagógico adequado para aumentar o desempenho dos estudantes (CROMPTON; BURKE, 2018). É importante destacar que os usuários de aplicativos móveis de comunicação podem trocar mensagens ou telefonemas 24 horas por dia, sete dias por semana, o que pode ser estressante e ansioso. Um autor (LEVY, 2006) concluiu que "estar constantemente acessível torna você inacessível", porque o uso extensivo de aplicativos móveis promove um estado de atenção parcial.

Portanto, estudos apontam que a rápida transição para teleodontologia e ensino emergencial remoto durante a pandemia foi uma experiência bem sucedida, e que pode continuar a ser utilizada. No entanto, fica claro que a teleodontologia não substituirá o atendimento presencial, devido ao caráter interventivo dos procedimentos, mas pode ser um complemento adicional importante na rotina dos clínicos dentistas e professores na área de saúde. Sua utilização demanda estudos mais aprofundados, a fim de explorar novas tecnologias em diferentes contextos e como elas podem impactar positivamente a sociedade na assistência oferecida pela área de saúde com qualidade e segurança.

Contribuição da autoria:

Glaucia N M Santos e Helbert Eustáquio C da Silva são estudantes de doutorado do programa de de pós-graduação em Odontologia da Universidade de Brasília e idealizaram o protótipo do aplicativo, realizaram a pesquisa bibliográfica e redigiram o manuscrito.

João Pedro Mota Jardim é graduado em Engenharia de Software e Vandor Roberto Vilardi Rissoli é professor de Engenharia de Software da Universidade de Brasília e ambos são membros do Laboratório de Tecnologias Educacionais (LaTEd). Foram responsáveis pelo desenvolvimento do protótipo do aplicativo e contribuíram com a parte de informática do manuscrito.

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CAPÍTULO 7 – DISCUSSÃO

7. Discussão

Os resultados deste trabalho demonstram que as medidas restritivas impostas pela pandemia impulsionaram o uso de ferramentas online de ensino e implementaram a evol

da Inteligência Artificial (IA). Como relatado no capítulo 2, o início da rápida transição entre o ensino presencial e o ensino online encontrou barreiras importantes dentro de um hospital de atenção quaternária de Brasília, exemplificada pela a falta de espaços adequados com conexão à Internet para transmissão das aulas online, o mediano conhecimento dos professores em relação ao uso de ferramentas online para o ensino de cirurgia buco-maxilo-facial e falta de motivação dos residentes, barreiras essas também relatadas em outros estudos[1,2] Nas universidades em todo o mundo, diferentes especialidades odontológicas tentaram contornar as consequências do distanciamento social por meio do desenvolvimento e aplicação de diversas ferramentas online de ensino, conforme relatado no capítulo 3, refletindo a importância da criatividade pedagógica dos docentes para o enfrentamento do período de emergência.

Denomina-se professor criativo aquele que inova diariamente em suas tarefas, que faz reflexões sobre suas aulas e as adapta com a finalidade de melhorar a aprendizagem dos alunos. Além disso, ele é capaz de criar um ambiente de comunicação que favoreça o processo de aprendizagem e que também contribua para o desenvolvimento dos discentes enquanto sujeitos[3]. Segundo Sefchovich & Waisburd[4], a criatividade é um sistema de atitudes capaz de se adaptar, quantas vezes seja necessário, para converter cada situação em uma possibilidade de aprendizagem e ensino. Ressalta-se que a maioria dos estudos relata o desenvolvimento da criatividade do aluno no ambiente escolar, sendo escassos os estudos direcionados ao professor criativo[3].

Pensando numa solução criativa voltada para amenizar as consequências do isolamento social dentro dos cursos de graduação em odontologia, no capítulo 4 foi proposta a ideia de um aplicativo de celular com dupla finalidade: a de teleassistência a pacientes, protagonizada por profissionais dentistas, e a de ensino em odontologia, por meio de simulações de atendimento oferecidas aos alunos, intermediadas por IA. O estudo apresenta o desenvolvimento de um protótipo, a ser validado após uso piloto. Apesar de o consenso de que os alunos têm mais fluência com a tecnologia do que os professores, pesquisas recentes[5,6] alertam que a familiaridade dos estudantes com a tecnologia é mais voltada para interações e entretenimento. Por isso, o papel do professor no desenvolvimento da autonomia dos estudantes na construção do conhecimento é fundamental. Ademais, apenas a experiência com aplicativos variados não é suficiente para a aprendizagem, o desenvolvimento da criticidade, da criatividade, do protagonismo e da ética são também essenciais para uma educação que propicie a formação de cidadãos para a construção de um mundo mais justo e solidário[7].

Com rápida evolução no período pandêmico, a IA se tornou uma forte aliada na área de saúde, em especial na área de radiologia[8,9]. O capítulo 5 demonstra que a ideia de sua inclusão nos currículos de radiologia diagnóstica já é um consenso, em especial devido à alta potencialidade da análise radiômica, capaz de auxiliar quantitativamente o radiologista na confecção de laudos. Por meio dela se avalia a textura de imagens digitais a partir de parâmetros estatísticos relacionados à distribuição e intensidade dos pixels ou voxels, ou relacionados à forma das lesões, com a finalidade de emitir um provável diagnóstico, prognóstico, ou sugerir ou avaliar uma resposta terapêutica[10,11]. Aplicado às alterações ósseas dos maxilares, o capítulo 6 oferece ao leitor os principais parâmetros utilizados em diferentes patologias ósseas dos maxilares, assim como as limitações e desafios encontrados para elaboração de boas análises radiômicas.

Numa perspectiva futura, existem fatores que enfatizam cada vez mais o uso da IA em saúde. Estima-se que cerca de 78,9% dos erros médicos seriam consequência de problemas na relação médico-paciente, de um exame clínico pouco eficiente, de falha de avaliação dos dados coletados, ou de deficiência de exames comprovando uma hipótese diagnóstica[12]. Soluções em a IA podem melhorar o atendimento por meio do emprego de sistemas para registrar dados em prontuários eletrônicos, para interpretação de exames de imagens e para apoio à decisão clínica orientando, a partir dos sintomas e sinais apresentados pelo paciente, hipóteses diagnósticas, exames e tratamentos a serem prescritos. Ainda, é possível a utilização de robôs em cirurgias, no acompanhamento de pacientes em domicílio, e implementação da telemedicina[8,12,13].

Considerando o uso de IA, é importante repensar as práticas de saúde. Para tanto, as mudanças deverão refletir um currículo ajustado a novas tecnologias[14]. O relatório "Creating a Community of Innovation – The work of the AMA accelerating change in medical education"[15] propõe os seguintes parâmetros para a imediata adaptação dos currículos: trabalho em equipe multidisciplinar, disponibilização de prontuários eletrônicos "ajustados" ao aprendizado de máquina, desenvolvimento de base de dados para dar suporte ao estudo de saúde da população, desenvolvimento de hábitos de estudo e auto avaliação do conhecimento, e uso da telemedicina. Além disso, várias universidades do mundo salientam a ênfase em educação continuada, com aprendizado flexível e adaptado ao projeto do aluno[12].

No entanto, o crescente desenvolvimento tecnológico no campo da IA tem levantado muitos questionamentos éticos. Em geral, os estudos com IA estão frequentemente apresentando limitações metodológicas que afetam diretamente sua transparência e replicabilidade[16]. Nos últimos cinco anos, diversos governos, universidades e empresas publicaram mais de 80 diretrizes voltadas para o uso responsável da IA, com vistas a aprimorar as pesquisas dentro dos preceitos éticos[17,18,19]. Uma revisão sistemática recente[17] mostrou que esses documentos convergem, mais especificamente, para os princípios da transparência, justiça e equidade, não maleficência, responsabilidade e privacidade. Um caminho em potencial para se construir mais conhecimento sobre a complexidade ética decorrente da introdução da IA no cotidiano seria conduzir mais estudos prospectivos, nos quais as decisões tomadas por IA possam ser comparadas àquelas feitas por profissionais de saúde. Isso poderia estimar o potencial real das soluções tecnológicas e prevenir afirmações exageradas de que os sistemas de IA são superiores às habilidades dos profissionais. Além disso, deveria ser encorajado ao corpo acadêmico que compartilhasse abertamente e rotineiramente seus códigos de algoritmos, a fim de permitir a reprodutibilidade dos estudos[20].

Portanto, embora auxilie a manter altos níveis de produtividade e de qualidade com precisão nas análises, a Organização Mundial de Saúde reconhece que a aplicação da IA na rotina médica esbarra em questões éticas, legais e sociais como o acesso equitativo, privacidade, uso apropriado da tecnologia e responsabilização sobre todos esses aspectos[21].

CONCLUSÃO

Conforme exposto, a tecnologia se mostrou uma grande aliada na manutenção do ensino em odontologia em meio às medidas restritivas impostas pela pandemia. Nesse período se observou também um impulso tecnológico, em especial na área de inteligência artificial, ferramenta com grande potencial para mudar as práticas em saúde. Cabe ressaltar que o fator humano, apesar do grande avanço tecnológico, é insubstituível. Portanto, a tecnologia é perigosa quando entendida apenas um instrumento em si, sem finalidade concreta ou desenvolvida para ludibriar o pensamento humano, mas deve ser utilizada como uma ferramenta auxiliar, para melhorar o desempenho em tarefas complexas, diminuindo erros e gasto de tempo em trabalhos repetitivos, além de dar mais segurança na tomada de decisões.

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Capítulo 8 – Trabalhos Relacionados

8. Trabalhos Relacionados

Esta seção é composta por três artigos relacionados aos temas tecnologia e teleassistência, dos quais participei como segunda autora.

No tema tecnologia, uma revisão do tipo *overview*[1] foi aceita para publicação, cuja finalidade foi avaliar a acurácia das ferramentas de IA na identificação precoce de tumores malignos em pacientes adultos, quando comparada com as modalidades convencionais de exames de imagens médicas. Nove artigos preencheram os critérios de elegibilidade e mostraram que a IA é promissora em termos de especificidade, sensibilidade e acurácia diagnóstica na detecção de tumores malignos. Apesar das limitações relacionadas à generalização para todos os tipos de câncer, a IA pode ajudar os profissionais, servindo inclusive como uma ferramenta de ensino para profissionais com pouco treinamento.

Já no âmbito da teleassistência, uma revisão integrativa[2] foi publicada com o objetivo de avaliar os benefícios do uso da teleodontologia para pacientes sob tratamento de câncer oral e de cabeça e pescoço durante a pandemia de COVID-19. Neste trabalho, 11 estudos foram averiguados em quatro categorias: visitas virtuais, uso da tecnologia remota, satisfação do paciente e abordagem multidisciplinar em teleodontologia. Foi observado que 78% dos pacientes preferiram a teleodontologia e que dois trabalhos apontaram melhora na qualidade de vida dos pacientes. Dentre os benefícios da teleodontologia, foram observadas a continuidade do cuidado odontológico, a redução do número de visitas aos hospitais e a consequente redução do risco de infecção pelo coronavírus tanto para pacientes quanto para profissionais.

Com a finalidade de avaliar a viabilidade da telessaúde no monitoramento de pacientes com câncer de cabeça e pescoço em relação ao aplicativo utilizado, a aderência e satisfação do usuário quanto à tecnologia, e a qualidade de vida do paciente, uma revisão sistemática[3] com oito artigos incluídos foi realizada. Apesar de diferentes aplicativos terem sido utilizados, os estudos mostraram que o monitoramento remoto e/ ou o próprio manejo dos sintomas por meio dos aplicativos de celular foi viável para a maioria dos pacientes, com graus satisfatórios de aceitabilidade, satisfação, usabilidade e aderência.

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2. da Silva HEC, Santos GNM, Leite AF, Mesquita CRM, de Souza Figueiredo PT, Dos Reis PED, Stefani CM, de Melo NS. The role of teledentistry in oral cancer patients during the COVID-19 pandemic: an integrative literature review. Support Care Cancer. 2021 Dec;29(12):7209-7223. doi: 10.1007/s00520-021-06398-0. Epub 2021 Jul 5. PMID: 34219196; PMCID: PMC8255116.

3. da Silva HEC, Santos GNM, Ferreira Leite A, Mesquita CRM, de Souza Figueiredo PT, Miron Stefani C, de Santos Melo N. The feasibility of telehealth in the monitoring of head and neck cancer patients: a systematic review on remote technology, user adherence, user satisfaction, and quality of life. Support Care Cancer. 2022 Oct;30(10):8391-8404. doi: 10.1007/s00520-022-07109-z. Epub 2022 May 6. PMID: 35524146.

CAPÍTULO 9 - PRESS RELEASE

9. Press Release

O presente trabalho versa sobre as alterações no ensino de odontologia e de atendimento a pacientes oncológicos ocorridas durante o isolamento social imposto pela pandemia de COVID-19, e como a tecnologia ajudou a amenizar essas consequências por meio do ensino emergencial remoto e da teleassistência, respectivamente.

Propõe o protótipo de um aplicativo de celular com dupla finalidade: ferramenta de ensino para alunos de graduação em odontologia por meio de simulação de atendimento de pacientes, e ferramenta de teleodontologia para acompanhamento remoto de pacientes reais.

Ainda, faz uma relevante reflexão sobre a pertinência de mudança curricular em radiologia diagnóstica, com a inclusão de inteligência artificial como ferramenta pedagógica e como área de conhecimento.

Com vistas a pesquisar melhorias tecnológicas em saúde, esse trabalho abrange também as possibilidades e perspectivas futuras do uso da inteligência artificial na leitura de exames diagnósticos por imagem, conhecido como análise radiômica (radiomics).

ANEXOS

ANEXO 1 - COMPROVANTE DE ACEITE DE ARTIGO

[Rev.ABENO] Decisão editorial Doutorado UnB ×

'Profa. Vania Regina Camargo Fontanella' via Revista da ABENO revabeno@gmail.com por emnuvens.com.br
para mim, Helbert, Hugo, Nilce

Prezados Autores

Temos a satisfação de informar que o artigo "Impact of Covid-19 in dental education: a research in residency in oral and maxillofacial surgery of the Federal District Public Health System." foi aceito para publicação na Revista da ABENO.

No anexo a prova editorial. Solicitamos fornecer as informações salientadas em vermelho na forma de notas autoadesivas no próprio arquivo e enviá-lo em resposta a este e-mail.

Atenciosamente

Profa. Vania Regina Camargo Fontanella
Faculdade de Odontologia, Universidade Federal do Rio Grande do Sul
vaniafontanella@terra.com.br

Revista da ABENO
http://revabeno.emnuvens.com.br/

Impact of COVID-19 in residency in Oral and Maxillofacial Surgery of the Federal District Public Health System

Glaucia Nize Martins Santos*; Helbert Eustáquio Cardoso da Silva; Hugo César Pinto Caracas***; Nilce de Santos Melo******

* PhD Student, Base Hospital Institute of the Federal District, Dentistry Department, Faculty of Health Science, University of Brasilia
** PhD Student, Dentistry Department, Faculty of Health Science, University of Brasilia
*** PhD, Professor of Orthodontics at the Base Hospital Institute of the Federal District, Brasilia
**** PhD, Professor of Stomatology, Dentistry Department, Faculty of Health Science, University of Brasilia

Received: 12/23/2020. Approved: 02/10/2021.

ABSTRACT

With the social isolation resulting from the coronavirus pandemic, the residency in Oral and Maxillofacial Surgery of the Federal District Public Health System adapted to maintain the attendance and course schedule. Theoretical classes migrated to online and there was an abrupt change in practical activities, such as the reduction in elective care and new biosafety protocols. The objective of this research was to understand the impact of the pandemic on the residency, including the analysis of perception and the level of satisfaction of the participants regarding online classes and practical activities, analysis of the number and type of surgeries performed in 2020 and residents' attitudes aimed for professional career, through Likert type questionnaires. Only half of the tutors and less than half of the residents were motivated to use the virtual teaching environment. In addition, the number of surgeries was reduced by more than 40%. In addition, half of the residents responded that they do not feel capable to resolve unexpected events related to their training and that they are not confident in making decisions regarding their professional career. COVID-19 will continue to have a greater impact on surgical practice, so hospitals should develop a detailed contingency plan, including for pandemics and schools should permanently incorporate options of complementary remote activities in their curriculum.

Descriptors: Education; Dentistry; Surgery, Oral; Coronavirus Infections; Internship and Residency.

Revista da ABENO • 21(1):1266, 2021 – DOI: 10.30979/rev.abeno.v21i1.1266

ANEXO 2 - COMPROVANTE DE ACEITE DE ARTIGO

Journal of Dental Education

Decision Letter (0070-Nov-20-JDE.R3)

From: Michael.Reddy@ucsf.edu
To: nize.gal@gmail.com, andreleite@unb.br
CC: Michael.Reddy@ucsf.edu
Subject: Journal of Dental Education - Decision on Manuscript ID 0070-Nov-20-JDE.R3
Body: 27-Feb-2021

Dear Ms. SANTOS:

It is a pleasure to accept your manuscript entitled "The Scope of Dental Education during COVID-19 pandemic: A Systematic Review" in its current form for publication in the Journal of Dental Education. The comments of the reviewers who reviewed your manuscript are included at the foot of this letter.

First Look: Please note that your manuscript files will now be checked to ensure that everything is ready for publication. You will be contacted with instructions if final versions of your files are required.

JDE is published by Wiley, Inc. The corresponding author will receive an email from Wiley asking them to register with Wiley's Author Services. Once registered, the corresponding author can sign a license agreement and monitor the article's progress through the production process.

Thank you for your fine contribution. On behalf of the Editors of the Journal of Dental Education, we look forward to your continued contributions to the Journal.

Sincerely,

Michael Reddy

Reviewer(s)' Comments to Author:

Date Sent: 27-Feb-2021

Received: 20 November 2020 | Revised: 21 February 2021 | Accepted: 27 February 2021
DOI: 10.1002/jdd.12587

ADEA | THE VOICE OF DENTAL EDUCATION WILEY

REVIEW ARTICLE

The scope of dental education during COVID-19 pandemic: A systematic review

Glaucia N. M. Santos DDS, MSc | Helbert E. C. da Silva DDS, MSc | André F. Leite DDS, MSc, PhD | Carla R. M. Mesquita DDS, MSc, PhD | Paulo T. S. Figueiredo DDS, MSc, PhD | Cristine M. Stefani DDS, MSc, PhD | Nilce S. Melo DDS, MSc, PhD

Department of Dentistry, Health Sciences Faculty, University of Brasilia, Brasilia, Brazil

Correspondence
Glaucia N. M. Santos, University Hospital of Brasilia. SGAN 605/606 Avenida L2 Norte 70840-901 Brasília/DF, Brazil.
Email: nize.gal@gmail.com

Abstract

Introduction: COVID-19 forced e-learning processes to develop abruptly and posed challenges to the educational infrastructure. Emergency Remote Teaching was designated to distinguish the new educational scheme. This concept involves production of online activities that may return to face-to-face format as soon as the isolation period ends.

Objective: From March through September of 2020, this systematic review attempted to elucidate experiences, benefits, and challenges enforced in dental education due to the pandemic, the learning technologies, and methods used to maintain education.

Methods: A literature search was conducted on Cochrane, Embase, Lilacs, Livivo, PubMed, Scopus, and Web of Science databases. Gray literature was also contemplated. Studies in which online teaching methods were described and dental learners were the subjects during pandemic were included.

Results: Learning technology, pedagogical model, knowledge gain, and dental learners' satisfaction and attitudes toward remote learning were assessed. The Joanna Briggs Institute JBI Critical Appraisal Checklist for Case Reports was applied as the methodological quality assessment to the 16 included studies. Assessments were related to demographic and historical characteristics of the participants, the intervention procedure, pre- and post-intervention descriptions, and identification of unanticipated events. All studies described the use of learning technology to ensure education continuity, and 15 studies highlighted the pedagogical model applied. Eight studies investigated knowledge gain while 12 searched the learners' satisfaction with online technologies.

Conclusion: The evidence suggests that learning technologies can support continuity in dental education. Reported problems include poor knowledge of faculty members on how to deal with technology, Internet connection, and content transition to online education.

KEYWORDS
coronavirus, Covid-19, dental education, dentistry, e-learning, emergency remote teaching, systematic review

ANEXO 3 - COMPROVANTE DE ACEITE DE ARTIGO

14/11/2022 08:14 Gmail - Your Submission AIED-D-22-00047R3 - [EMID:b10268067bca7afa]

Gmail **Gláucia Nize Martins <nize.gal@gmail.com>**

Your Submission AIED-D-22-00047R3 - [EMID:b10268067bca7afa]

1 mensagem

International Journal of Artificial Intelligence in Education 11 de novembro de 2022 06:57
<em@editorialmanager.com>
Responder a: International Journal of Artificial Intelligence in Education <jesson.austria@springer.com>
Para: Glaucia Nize Martins Santos <nize.gal@gmail.com>

CC: mike.sharples@open.ac.uk

Dear Ms Santos,

Congratulations! We are pleased to inform you that your manuscript, "The Introduction of Artificial Intelligence in diagnostic radiology curricula: a text and opinion systematic review.", has been accepted for publication in the International Journal of Artificial Intelligence in Education.

You will receive an e-mail in due course regarding the production process.

Please remember to quote the manuscript number, AIED-D-22-00047R3, whenever inquiring about your manuscript.

With best regards,

Mike - Sharples, PhD, BSc
Associate Editor

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Authors may need to take specific actions to achieve compliance with funder and institutional open access mandates. If your research is supported by a funder that requires immediate open access (e.g. according to Plan S principles) then you should select the gold OA route, and we will direct you to the compliant route where possible. For authors selecting the subscription publication route our standard licensing terms will need to be accepted, including our self-archiving policies. Those standard licensing terms will supersede any other terms that the author or any third party may assert apply to any version of the manuscript.

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International Journal of Artificial Intelligence in Education
https://doi.org/10.1007/s40593-022-00324-z

ARTICLE

The Introduction of Artificial Intelligence in Diagnostic Radiology Curricula: a Text and Opinion Systematic Review

Glaucia Nize Martins Santos[1] · Helbert Eustáquio Cardoso da Silva[1] · Paulo Tadeu de Souza Figueiredo[1] · Carla Ruffeil Moreira Mesquita[1] · Nilce Santos Melo[1] · Cristine Miron Stefani[1] · André Ferreira Leite[1]

Accepted: 11 November 2022

Abstract

Background Artificial intelligence (AI) is able to emulate human performance on a task and may improve the radiologists' work. This text and opinion review explored the implementation of AI in diagnostic radiology education curricula at pre-licensure training/education in healthcare. The question was: what are the pedagogical possibilities, advantages and challenges of AI use in diagnostic radiology education?

Methods Primary research studies, reviews, systematic reviews, meta-analyses, letters, texts, expert opinions, expert consensus, discussion papers and guidelines about diagnostic radiology education at the undergraduate and postgraduate levels of any field of health sciences were considered. Searches were conducted on indexed databases and grey literature. Data on the context, potentials and challenges were collected from the text and opinion papers and the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Text and Opinion Papers was applied to assess methodological quality. From the experience papers, intervention, experiences and results were extracted parameters and an adapted JBI Critical Appraisal Checklist for Case Reports was applied.

Results Seventeen studies met the inclusion criteria. Personalization, training facilities and the standardization of radiology teaching were the main potentials identified. Five main challenges were also observed: the validation of AI tools in radiology education, the learning curve, universities' aptitude to teach AI, the digitization of radiological images and how to include AI in radiology curricula.

Conclusion The necessity to update radiology curricula to include AI is a consensus. Time is required for development of the learning curve among AI developers, teachers and trainees. When and to what extent AI should be taught in radiology courses needs further exploration.

Keywords Radiology · Education · Curriculum · Artificial Intelligence · Machine Learning

Extended author information available on the last page of the article

ANEXO 4 - COMPROVANTE DE ACEITE DE ARTIGO

Date: 02 Oct 2022
To: "Glaucia Nize Martins Santos" nize.gal@gmail.com
From: "DMFR Office" michael.bornstein@unibas.ch
Subject: Your submission DMFR-D-22-00225R1

Dear Dr Santos,

I am pleased to inform you that your paper "Radiomics in bone pathology of the jaws: a systematic review," has been accepted in its present form for exclusive publication in Dentomaxillofacial Radiology.

You will receive proofs in due course.

Dentomaxillofacial Radiology offers authors of accepted articles the option to have their article published open access subject to an article processing charge. For more information, please see:

http://www.birjournals.org/site/policy/open_access_policy.xhtml

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* For NIH-funded authors:

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Please note DMFR now uses a continuous publication model, please see brief explanation at the bottom of this e-mail for more information.

Thank you for submitting your work to this journal.

Yours sincerely,
Dr. Gang Li
Associate Editor
Dentomaxillofacial Radiology

DMFR has moved to continuous publication from 2013. Continuous publication is article-based publishing as opposed to issue-based publishing. When an article is in its final form, rather than waiting for the article to be in a print issue before it is technically published, the article is published in its final form online. The Version of Record will be the online article and accepted articles are cited using a volume and article identifier (for example 10.1259/dmfr.XXXXXX) rather than a traditional issue and page number The benefit to authors is that acceptance to publication time will be reduced and there is no more waiting for the article to appear in a finalised issue before it is technically published. This modern publishing model will allow our titles to achieve an even faster 'Speed to Publication', benefitting our authors in disseminating their research as soon as possible.

Dentomaxillofacial Radiology (2022) 51, 20220225

birpublications.org/dmfr

SYSTEMATIC REVIEW

Radiomics in bone pathology of the jaws: a systematic review

[1]Glaucia Nize Martins Santos, [1]Helbert Eustáquio Cardoso da Silva, [2]Filipe Eduard Leite Ossege, [1]Paulo Tadeu de Souza Figueiredo, [1]Nilce de Santos Melo, [1]Cristine Miron Stefani and [1]André Ferreira Leite

[1]Dentistry Department, Faculty of Health Science, University of Brasilia, Brasilia, Brazil; [2]Mechanical Engineering Department, Faculty of Technology, University of Brasília, Brasília, Brazil

Objective: To define which are and how the radiomics features of jawbone pathologies are extracted for diagnosis, predicting prognosis and therapeutic response.

Methods: A comprehensive literature search was conducted using eight databases and gray literature. Two independent observers rated these articles according to exclusion and inclusion criteria. 23 papers were included to assess the radiomics features related to jawbone pathologies. Included studies were evaluated by using JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies.

Results: Agnostic features were mined from periapical, dental panoramic radiographs, cone beam CT, CT and MRI images of six different jawbone alterations. The most frequent features mined were texture-, shape- and intensity-based features. Only 13 studies described the machine learning step, and the best results were obtained with Support Vector Machine and random forest classifier. For osteoporosis diagnosis and classification, filtering, shape-based and Tamura texture features showed the best performance. For temporomandibular joint pathology, gray-level co-occurrence matrix (GLCM), gray level run length matrix (GLRLM), Gray Level Size Zone Matrix (GLSZM), first-order statistics analysis and shape-based analysis showed the best results. Considering odontogenic and non-odontogenic cysts and tumors, contourlet and SPHARM features, first-order statistical features, GLRLM, GLCM had better indexes. For odontogenic cysts and granulomas, first-order statistical analysis showed better classification results.

Conclusions: GLCM was the most frequent feature, followed by first-order statistics, and GLRLM features. No study reported predicting response, prognosis or therapeutic response, but instead diseases diagnosis or classification. Although the lack of standardization in the radiomics workflow of the included studies, texture analysis showed potential to contribute to radiologists' reports, decreasing the subjectivity and leading to personalized healthcare.
Dentomaxillofacial Radiology (2022) **51**, 20220225. doi: 10.1259/dmfr.20220225

Cite this article as: Santos GNM, da Silva HEC, Ossege FEL, Figueiredo PTS, Melo NS, Stefani CM, et al. Radiomics in bone pathology of the jaws: a systematic review. *Dentomaxillofac Radiol* (2022) 10.1259/dmfr.20220225.

Keywords: Radiomics; Jaws; Texture analysis; Bone; Systematic Review

Introduction

Radiomics is the process of extracting quantitative information from radiological images, and is designed to develop decision-support tools, taking a central role in the context of personalized precision medicine. Mining data from digital images and combine them with other patient characteristics promises to increase precision in diagnosis, assessment of prognosis, and prediction of therapy response[1–5].

Radiomic analysis begins with the choice of a high-quality imaging protocol. Such imaging methods include X-ray, CT, MRI, Nuclear Medicine, Positron Emission

Correspondence to: Dr Glaucia Nize Martins Santos, E-mail: nize.gal@gmail.com

Received 29 June 2022; revised 02 September 2022; accepted 02 October 2022

ANEXO 5 - COMPROVANTE DE ACEITE DE ARTIGO

Gmail

Gláucia Nize Martins <nize.gal@gmail.com>

[CLIUM] Decisão editorial

5 mensagens

Revista Concilium <revista@clium.org> 15 de agosto de 2023 às 15:15

Para: Glaucia Nize Martins Santos <nize.gal@gmail.com>, Helbert Eustáquio Cardoso da Silva <helbertcardososilva@gmail.com>, João Pedro Mota Jardim <jpmota.unb@gmail.com>, Vandor Roberto Vilardi Rissoli <vandorissoli@gmail.com>, André Ferreira Leite <andreleite@unb.br>, Nilce Santos de Melo <nilce@unb.br>

Glaucia Nize Martins Santos, Helbert Eustáquio Cardoso da Silva, João Pedro Mota Jardim, Vandor Roberto Vilardi Rissoli, André Ferreira Leite, Nilce Santos de Melo:

Nós chegamos a uma decisão referente a sua submissão para o periódico Concilium, "Dentech: A mobile application for remote care and teaching in Dentistry: Dentech: Um aplicativo de celular para assistência à saúde e ensino em Odontologia de forma remota".

Nossa decisão é de: Aceitar a Submissão

____

Revista Concilium
Equipe de editores
https://clium.org/

DOI: 10.53660/CLM-1824-23M47

Dentech: A mobile application for remote care and teaching in Dentistry

Dentech: Um aplicativo de celular para assistência à saúde e ensino em Odontologia de forma remota

Received: 2023-07-16 | Accepted: 2023-08-18 | Published: 2023-08-21

Glaucia Nize Martins Santos
ORCID: https://orcid.org/0000-0002-9955-4323
Universidade de Brasília, Brasil
E-mail: nize.gal@gmail.com
Helbert Eustáquio Cardoso da Silva
ORCID: https://orcid.org/0000-0003-2662-6987
Universidade de Brasília, Brasil
E-mail: helbertcardososilva@gmail.com
João Pedro Mota Jardim
ORCID: https://orcid.org/0009-0002-4276-1521
Universidade de Brasília, Brasil
E-mail: jpmota.unb@gmail.com
Vandor Roberto Vilardi Rissoli
ORCID: https://orcid.org/0009-0000-2824-3395
Universidade de Brasília, Brasil
E-mail: vandorissoli@gmail.com
André Ferreira Leite
ORCID: https://orcid.org/0000-0002-7803-4740
Universidade de Brasília, Brasil
E-mail: andreleite@unb.br
Nilce Santos de Melo
ORCID: https://orcid.org/0000-0001-7268-485X
Universidade de Brasília, Brasil
E-mail: nilce@unb.br

ABSTRACT

OBJECTIVE: to create a complementary digital tool for remote health care and teaching in Dentistry. METHOD: a mobile application prototype combining m-health and m-learning was developed, using free resources. RESULT: the prototype has three different profiles related to oral health: Dentist, Professor Dentist and Student. With the prototype, it is possible for the Dentist to exchange information with patients via Whatsapp and save information in electronic medical records. Also, the prototype allows the Professor Dentist to develop clinical scenarios, make them available for assistance simulations to the Student profile, and evaluate the resulting interactions later. CONCLUSION: technology is an important part of our daily lives and improves information and communication. Despite the advantages, its use is still challenging due to limited technological knowledge, in addition to the precariousness of the Internet connection in a general way.

Keywords: Teledentistry; Dentistry Education; Mobile Application; Simulation Training; Remote Learning.

ANEXO 6 - COMPROVANTE DE ACEITE DE ARTIGO

22/10/2022 16:14 Gmail - Re: JSCC-D-20-02027R2 - Accepted - [EMID:817668f32e38cbd1]

Gmail **Gláucia Nize Martins <nize.gal@gmail.com>**

Re: JSCC-D-20-02027R2 - Accepted - [EMID:817668f32e38cbd1]
1 mensagem

HELBERT SILVA <helbertcardososilva@gmail.com> 24 de junho de 2021 07:44
Para: Nilce Melo <nilcesantosmelo@gmail.com>, Nilce <nilce@unb.br>, Gláucia Nize Martins <nize.gal@gmail.com>, André Leite <andreleite@unb.br>, Paulo Tadeu de <paulofigueiredo@unb.br>, Carla Ruffeil <carlarm@globo.com>, Cristine Stefani <cmstefani@gmail.com>, Paula Elaine Diniz dos Reis <pauladiniz@unb.br>

Em qua., 23 de jun. de 2021 às 18:49, Fred Ashbury <em@editorialmanager.com> escreveu:

> Date: 23 Jun 2021
>
> Manuscript No: JSCC-D-20-02027R2
> Title: The Role of Teledentistry in Oral Cancer Patients During the COVID-19 Pandemic: an integrative literature review.
> by HELBERT EUSTÁQUIO CARDOSO DA SILVA; Gláucia Nize Martins Santos; André Ferreira Leite; Carla Ruffeil Moreira Mesquita; Paulo Tadeu de S Figueiredo; Paula Elaine Diniz dos Reis; Cristine Miron Stefani; Nilce dos Santos Melo
>
> Dear Mr SILVA,
>
> We are pleased to inform you that your above mentioned manuscript has been accepted for publication in Supportive Care in Cancer.
>
> The manuscript will now be forwarded to the publisher, from whom you will shortly receive information regarding the correction of proofs and fast online publication.
>
> Should you have any questions regarding publication of your paper, please contact the responsible production editor, Ms. Annalyn Marabillo at Annalyn.Marabillo@springer.com.
>
> With best regards,
> Dr. Fred Ashbury
> Editor-in-Chief,
> Supportive Care in Cancer

Supportive Care in Cancer
https://doi.org/10.1007/s00520-021-06398-0

REVIEW ARTICLE

The role of teledentistry in oral cancer patients during the COVID-19 pandemic: an integrative literature review

Helbert Eustáquio Cardoso da Silva[1,2] · Glaucia Nize Martins Santos[1] · André Ferreira Leite[1] · Carla Ruffeil Moreira Mesquita[1] · Paulo Tadeu de Souza Figueiredo[1] · Paula Elaine Diniz dos Reis[3] · Cristine Miron Stefani[1] · Nilce Santos de Melo[1]

Received: 26 December 2020 / Accepted: 23 June 2021

Abstract

Objectives This integrative review aimed to assess the benefits of the use of teledentistry for patients undergoing treatment of oral and head and neck cancer during the COVID-19 pandemic.

Materials and methods We searched in PubMed, Cochrane, Scopus, Web of Science, Lilacs, Embase, Open Grey, Google Scholar, and Jstor databases for studies referring to the management, control, and assistance, through teledentistry, to patients with oral and head and neck cancer during the COVID-19 pandemic.

Results We found 356 references in the databases, 209 after duplicates removal, 23 met criteria for full-text reading, and 11 studies were included for qualitative synthesis, in four categories: virtual visits, use of remote technology, patient's satisfaction, multidisciplinary approach in teledentistry. We found that 78% of patients currently preferred teledentistry; 92% of patients would recommend the use of video consultation to other patients. The continuity of dental care, the reduction of patient visits to the hospital, the reduction of the risk of infection with the coronavirus, and limitation of face-to-face consultations to protect health professionals are benefits that reinforce the use of teledentistry by health institutions. Two studies showed patients' satisfaction with the use of teledentistry in monitoring cancer patients and showed an improvement in quality of life.

Conclusions The teledentistry, as a remote technology for monitoring patients with oral and head and neck cancer, is well accepted by patients in preliminary studies. Although these studies pointed out some benefits of using remote technologies for the care of cancer patients, further robust scientific evidence is still needed in this regard.

Keywords COVID-19 · Teledentistry · Telemedicine · Oral cancer · Head and neck cancer · Integrative review

✉ Helbert Eustáquio Cardoso da Silva
helbertcardososilva@gmail.com

Glaucia Nize Martins Santos
nize.gal@gmail.com

André Ferreira Leite
andreleite@unb.br

Carla Ruffeil Moreira Mesquita
ruffeilcarla@gmail.com

Paulo Tadeu de Souza Figueiredo
paulofigueiredo@unb.br

Paula Elaine Diniz dos Reis
pauladiniz@unb.br

Cristine Miron Stefani
cmstefani@gmail.com

Nilce Santos de Melo
nilce@unb.br

1 Dentistry Department, Faculty of Health Science, Brasilia University, Brasilia, Brazil

2 UnB - Campus Universitário Darcy Ribeiro, Braisilia, DF 70910-900, Brazil

3 Nursing Department, Faculty of Health Science, Brasilia University, Brasilia, Brazil

Published online: 05 July 2021

ANEXO 7 - COMPROVANTE DE ACEITE DE ARTIGO

Gmail

Gláucia Nize Martins <nize.gal@gmail.cc

Re: JSCC-D-21-01905R2 - Accepted - [EMID:7b781fdebb7ed9e7]
1 mensagem

HELBERT SILVA <helbertcardososilva@gmail.com> — 24 de outubro de 2022 1(
Para: Gláucia Nize Martins <nize.gal@gmail.com>

Em sáb., 30 de abr. de 2022 às 18:50, Fred Ashbury <em@editorialmanager.com> escreveu:

> Date: 30 Apr 2022
>
> Manuscript No: JSCC-D-21-01905R2
> Title: The feasibility of Telehealth in the monitoring of head and neck cancer patients: a systematic review on remote technology, user adherence, user satisfaction, and quality of life
> by HELBERT EUSTÁQUIO CARDOSO DA SILVA; Glaucia Nize Martins Santos; André Ferreira Leite; Carla Ruffeil Moreira Mesquita; Paulo Tadeu de Souza Figueiredo; Cristine Miron Stefani; Nilce de Santos Melo
>
> Dear Mr SILVA,
>
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REVIEW ARTICLE

The feasibility of telehealth in the monitoring of head and neck cancer patients: a systematic review on remote technology, user adherence, user satisfaction, and quality of life

Helbert Eustáquio Cardoso da Silva[1,2] · Glaucia Nize Martins Santos[1] · André Ferreira Leite[1] · Carla Ruffeil Moreira Mesquita[1] · Paulo Tadeu de Souza Figueiredo[1] · Cristine Miron Stefani[1] · Nilce de Santos Melo[1]

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Abstract

Objectives This systematic review aimed to analyze the use of telehealth in monitoring patients with head and neck cancer regarding the application used, user adherence to technology, user satisfaction, and user quality of life.

Materials and methods A search strategy was developed using the PICO acronym and the terms "Head and Neck Cancer," "Telehealth," "Mobile Application," and "Supportive Care." A broad literature search was performed on PubMed, Cochrane Library, Scopus, Web of Science, Lilacs, and Embase databases and on grey literature through Open Grey, Google Scholar, and Jstor, for studies comparing the monitoring of head and neck cancer patients with telehealth apps to the monitoring performed in a traditional way at health units. No study design, publication status, publication time, or language restrictions were applied. Pairs of reviewers worked independently for study selection and risk of bias assessment. The protocol was registered in PROSPERO and the PRISMA checklist used for reporting the review.

Results We found 393 references in the databases, 325 after duplicate removal; 19 met the criteria for full-text reading; 08 studies were included for qualitative synthesis. Although there was heterogeneity regarding the technology used, the studies included showed that remote monitoring and/or self-management of symptoms through mobile applications was feasible for most patients, with satisfactory degrees of acceptability, satisfaction, usability, and adherence. The health-related quality of life improved with the use of remote technologies for telehealth, associated with low to moderate self-efficacy, higher personal control, and higher knowledge of health with clinically acceptable levels of accuracy compared to traditional clinical evaluation. Even when the data presented were not statistically significant, patients reported improvement in health-related quality of life after the intervention.

Conclusions Telehealth monitoring through the use of remote technologies presents itself as an alternative way of educating and supporting patients during the treatment of Head and Neck Cancer (HNC). There is the need for a more user-friendly interface, adequate user experience assessment, and the concrete applicability of telehealth technologies for monitoring patients with HNC in order to legitimize the cost-effectiveness of developing long-term multicenter longitudinal studies term.

Keywords Telehealth · Oral cancer · Head and neck cancer · Monitoring · Systematic review

✉ Helbert Eustáquio Cardoso da Silva
helbertcardososilva@gmail.com

Glaucia Nize Martins Santos
nize.gal@gmail.com

André Ferreira Leite
andreleite@unb.br

Carla Ruffeil Moreira Mesquita
ruffeilcarla@gmail.com

Paulo Tadeu de Souza Figueiredo
paulofigueiredo@unb.br

Cristine Miron Stefani
cmstefani@gmail.com

Nilce de Santos Melo
nilce@unb.br

1 Dentistry Department, Faculty of Health Science, Brasilia University, Brasilia, Brazil

2 UnB - Campus Universitário Darcy Ribeiro, Brasília, DF 70910-900, Brazil

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ANEXO 8 - COMPROVANTE DE ACEITE DE ARTIGO

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The use of artificial intelligence tools in cancer detection compared to the traditional diagnostic imaging methods: an overview of the systematic reviews

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RESEARCH ARTICLE

The use of artificial intelligence tools in cancer detection compared to the traditional diagnostic imaging methods: An overview of the systematic reviews

Helbert Eustáquio Cardoso da Silva*[©], Glaucia Nize Martins Santos[©], André Ferreira Leite[‡], Carla Ruffeil Moreira Mesquita[‡], Paulo Tadeu de Souza Figueiredo[‡], Cristine Miron Stefani[©], Nilce Santos de Melo[©]

Faculty of Health Science, Dentistry of Department, Brasilia University, Brasilia, Brazil

© These authors contributed equally to this work.
‡ These authors also contributed equally to this work
* helbertcardososilva@gmail.com

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Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Abstract

Background and purpose

In comparison to conventional medical imaging diagnostic modalities, the aim of this overview article is to analyze the accuracy of the application of Artificial Intelligence (AI) techniques in the identification and diagnosis of malignant tumors in adult patients.

Data sources

The acronym PIRDs was used and a comprehensive literature search was conducted on PubMed, Cochrane, Scopus, Web of Science, LILACS, Embase, Scielo, EBSCOhost, and grey literature through Proquest, Google Scholar, and JSTOR for systematic reviews of AI as a diagnostic model and/or detection tool for any cancer type in adult patients, compared to the traditional diagnostic radiographic imaging model. There were no limits on publishing status, publication time, or language. For study selection and risk of bias evaluation, pairs of reviewers worked separately.

Results

In total, 382 records were retrieved in the databases, 364 after removing duplicates, 32 satisfied the full-text reading criterion, and 09 papers were considered for qualitative synthesis. Although there was heterogeneity in terms of methodological aspects, patient differences, and techniques used, the studies found that several AI approaches are promising in terms of specificity, sensitivity, and diagnostic accuracy in the detection and diagnosis of malignant tumors. When compared to other machine learning algorithms, the Super Vector Machine method performed better in cancer detection and diagnosis. Computer-assisted detection (CAD) has shown promising in terms of aiding cancer detection, when compared to the traditional method of diagnosis.