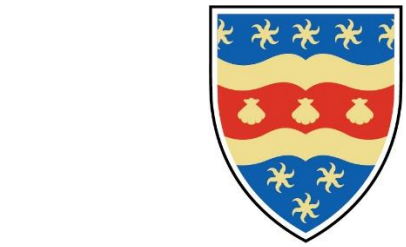
Appendix A: Review protocol



UNIVERSITY OF PLYMOUTH

Faculty of Health

Artificial Intelligence and dental service provision: a rapid evidence assessment

Review protocol

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Sally Hanks, Mona Nasser, Shangming Zhou

Introduction

The phenomenon of interest for this review is **artificial intelligence (AI) in dental service provision**.

AI is 'technology that enables computers and machines to simulate human learning, comprehension, problem-solving, decision-making, creativity and autonomy.' [13] AI has developed through several phases, each with increased functionalities: from machine learning systems that learn from data; to deep learning models that simulate human brain function; and to generative AI models that can create original content.

Dental service provision encompasses oral health care provided by dentists and other dental care professionals (DCPs) in both the public and private sectors, in primary and secondary care settings. [14]

A number of prior reviews have been conducted in relation to AI and dentistry. A 2021 review found AI to be a reliable tool for use in dental care but that further research to assess clinical performance of AI techniques was necessary.[65] Another review reported AI models being used in detection and diagnosis of dental caries, vertical root fractures, cancerous lesions, and predicting orthodontic extractions, among other applications.[66] Other reviews have considered the role of AI in specific fields of dentistry, including restorative dentistry[67] and endodontics[68], and other matters such as ethics.[69] However these previous reviews do not sufficiently address our specific objectives. In addition, given the very rapid pace of development in the field of AI, the existing reviews are already out of date as there is a new body of literature to be synthesised.

The aim of this Rapid Evidence Assessment (REA) is to generate an evidence base providing learning about current issues relating to AI and use of AI in dental service provision and about potential future areas of development.

The REA's objectives are:

- To identify and synthesize evidence about applications of AI in dental service provision, including its impact, benefits, best practice, risks and challenges, and implications for equality, diversity and inclusion (EDI) and data protection, as well as its prevalence, profile, and reasons for its use.
- To identify and assess evidence about potential developments of AI in dental service provision.
- To identify and describe methods used to evaluate the role and impacts of AI in dental service provision.

- To identify gaps in the evidence base on AI in dental service provision and recommend priority areas for further research.

Review questions

We will conduct a rapid evidence assessment to answer the question:

1) What applications of AI are currently implemented in dental service provision and which areas provide promising opportunities for the future?

Supplementary questions to be addressed are:

2) Are there any best practice guidelines for specific technologies that use AI in dental service provision?

3) Which of the technologies that use AI in dental service provision have shown effectiveness in experimental studies?

4) What are the risks and challenges associated with technologies using AI in dental service provision? Are there any strategies and interventions suggested to address those challenges?

5) What methods have been used to evaluate AI in dental service provision?

Methodology

This review will be conducted as a rapid evidence assessment (REA), an approach to evidence synthesis that bridges the structured, rigorous design of systematic review methods with policymakers' needs for fast-paced information on a particular topic. We will draw on Varker's[70] REA methodology, and will conform to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA)[71] guidelines when reporting the study.

Search strategy

Peer-reviewed literature

An experienced information specialist (LB) will develop a search strategy combining terms related to artificial intelligence and terms related to dental service provision. We will focus on published academic literature in order to identify evidence that has been peer-reviewed to provide a degree of quality assurance. We propose searching the following bibliographic databases: MEDLINE, Embase, CINAHL, DOSS, Scopus, IEEE Xplore, and Web of Science. An example of the search strategy in Embase can be seen in appendix 1.

To focus the searches, we will search for keywords in titles, abstracts and subject headings. We will search for literature published from 2020 to the present, published internationally, due to the potential for novel technological innovations to spread quickly between countries. A 2023 bibliometric review on AI in healthcare found that over 96% of studies were published in 9 countries with over 40% from the USA alone.[72] We will search for evidence relating to dentistry only as extending beyond this into other health sectors would produce very high quantities of literature with unknown applicability to dentistry, making the REA unachievable within the timeframe. We will exclude prior literature reviews, as these are now out-of-date and unlikely to address our exact questions.

Pre-print literature

Following the primary searches of peer-reviewed literature, we will also search relevant pre-print repositories (medRxiv; Research Square; JMIR Preprints, Preprints with The Lancet, OSF Preprints, Preprints.org, SciELO Preprints, bioRxiv, arXiv) in order to identify the most up-to-date literature available. For these platforms, we will use a simplified version of the search strategy due to the reduced functionality of these interfaces. Items retrieved via these searches will be considered separately to the peer-reviewed literature, and any un-reviewed content included in the final REA report will be annotated.

Screening and evidence selection

Evidence selection process

The search results will be imported into Endnote reference manager software (LB). Following deduplication, the references will be exported into Rayyan, a systematic review application. Screening will be undertaken by three reviewers (HA, LB, MB). First, a calibration exercise will be completed, where each reviewer will independently screen the same 10% of the returned items. Screening results will then be compared, and any disagreements or uncertainty about the application of the selection criteria will be resolved through discussion among the research team. Following this calibration exercise, the remaining search results will be split among the three reviewers for screening.

Next, the same three reviewers will screen the full texts of papers included after title/abstract screening, using the same selection criteria. Again, a calibration exercise will be undertaken with 20% of the items included after the title and abstract screening stage. Inter-rater agreement will be checked, and any discrepancies will be discussed between the three reviewers. In the event that a

decision cannot be reached through discussion between reviewers, papers will be referred to the wider research team for discussion and an agreement on inclusion or exclusion will be reached. Following the calibration exercise, the remaining items will be divided between the three reviewers and screened. At the full-text screening stage, reasons for exclusion will be recorded.

Screening decisions will be recorded in line with PRISMA guidelines, and the selection process will be reported using a PRISMA flowchart diagram.

Evidence selection criteria

The review will use a PICOC (Population, Intervention, Comparison, Outcomes, Context) framework to structure the inclusion and exclusion criteria, as set out in table 1. There are additional inclusion and exclusion criteria relating to study type, to align with our focus on including studies providing evidence about the implementation of AI in dental service provision while excluding non-empirical publication types such as editorials, letters, and commentaries.

Prior literature reviews will not be included in the data extraction or evidence synthesis to avoid the risk of double-reporting results. However, these may be considered for the background they provide and may be considered in the discussion section of the synthesis.

Table 1: Inclusion and exclusion criteria

Category	**Inclusion**	**Exclusion**
Population	Dental professionals; dental patients;	Dental education and training
Intervention	AI; machine learning; deep learning; natural language processing; large language models; generative pre-trained transformer; transformer; supervised machine learning; unsupervised machine learning	
Comparison	*Not applicable*	
Outcomes	Prevalence; impact; benefits; risks; equality, diversity and inclusion; data protection.	
Context	International; dental services settings; dental care	Dental students

Study design	All study designs reporting empirical data (quantitative or qualitative) on implementation of AI in dental services	Literature reviews; grey literature; editorials; commentaries; letters; conference abstracts.
Language	English	
Date range	2020 to present	

Critical appraisal

Due to the strict timeframe for the study, no formal critical appraisal will be performed. As this REA is not explicitly comparing or measuring the effectiveness of particular interventions, critical appraisal is not required.

Data extraction

We will develop a standardized data extraction form to collate information from included literature. Data will be extracted on source/author, year of publication, study design, population/setting, AI applications, outcome measures, impact metrics, and any other pertinent information relating to the review questions. Depending upon the quantity of literature included for review, data will be extracted by a single reviewer (AH), or with assistance from a second reviewer (MB). Should any uncertainty arise over the inclusion of data, this will be resolved through discussion among the research team.

Data synthesis

Synthesis of the results will be undertaken by HA, consulting MB where necessary. QSR Nvivo14 software will be used to code the included articles and to facilitate data synthesis. The data will be synthesised narratively to address the review questions, with data also presented in tabular and/or graphical formats where appropriate. In the synthesis, we will also seek to identify AI interventions that have been implemented in the UK specifically, and then to highlight developments in countries with similar healthcare contexts which may be more readily transferable to the UK. The synthesis will also highlight successful applications of AI, and any barriers to the implementation of AI applications that may be identified. We will also identify challenges and risks relating to the implementation of AI, including consideration of any particular implications for regulation where these arise.

Dissemination

The findings from this review will be reported to the funder to be published, and then written as an academic article for peer-reviewed publication.

Appendix 1: Example search strategy

Embase <1974 to 2024 August 30>

1 artificial intelligence/ 85351

2 artificial intelligence.tw. 56310

3 machine learning/ 130764

4 machine learning.tw. 126359

5 deep learning/ 63059

6 deep learning.tw. 69731

7 (AI-powered or AI-driven or AI-enabled).tw. 2670

8 natural language processing/ 13745

9 natural language processing.tw. 10123

10 large language model/ 2072

11 large language model*.tw. 2600

12 generative pretrained transformer/ 349

13 transformer*.tw. 9686

14 BERT.tw. 1543

15 GPT*.tw. 9449

16 (T5 not (T5 adj9 (T0 or T4 or T1 or baseline or minutes or hour* or day* or week* or month* or year*))).tw. 5394

17 RoBERTa.tw. 352

18 XLNet.tw. 26

19 ALBERT.tw. 4286

20 BART.tw. 1530

21 DistilBERT.tw. 32

22 GLaM.tw. 67

23 LLaMA.tw. 1545

24 artificial intelligence chatbot/ 416

25 Chatbot.tw. 1270

26 supervised machine learning/ 5486

27 unsupervised machine learning/ 3545

28 (supervised learning or unsupervised learning).tw. 9061

29 robotics/ 49337

30 robot*.tw. 115426

31 or/1-30 445799

32 exp dentistry/ 111149

33 (dentistry or dental).tw. 289264

34 (periodont* or endodont* or orthodont* or prosthodont* or "oral surgery").tw. 167933

35 32 or 33 or 34 445506

36 31 and 35 2380

37 limit 36 to (english language and yr="2020 -Current") 1816

38 (review or letter or note or editorial).pt. 6436522

39 37 not 38 1463

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Appendix B: Search strategies

Ovid Embase <1996 to 2024 Week 37>

1	artificial intelligence/	84087
2	artificial intelligence.tw.	55456
3	machine learning/	127604
4	machine learning.tw.	122974
5	deep learning/	60750
6	deep learning.tw.	67446
7	(AI-powered or AI-driven or AI-enabled).tw.	2647
8	natural language processing/	13376
9	natural language processing.tw.	9805
10	large language model/	1845
11	large language model*.tw.	2295
12	generative pretrained transformer/	339
13	transformer*.tw.	8809
14	BERT.tw.	1428
15	GPT*.tw.	6193
16	(T5 not (T5 adj9 (T0 or T4 or T1 or baseline or minutes or hour* or day* or week* or month* or year*))).tw.	4637
17	RoBERTa.tw.	330
18	XLNet.tw.	24
19	ALBERT.tw.	3598
20	BART.tw.	1469
21	DistilBERT.tw.	32
22	GLaM.tw.	68
23	LLaMA.tw.	1316
24	artificial intelligence chatbot/	420
25	Chatbot.tw.	1254

26	supervised machine learning/	5352
27	unsupervised machine learning/	3447
28	(supervised learning or unsupervised learning).tw.	8753
29	robotics/	48743
30	robot*.tw.	114598
31	or/1-30	431890
32	exp dentistry/	75298
33	(dentistry or dental).tw.	224752
34	(periodont* or endodont* or orthodont* or prosthodont* or "oral surgery").tw.	134386
35	32 or 33 or 34	336795
36	31 and 35	2327
37	limit 36 to (english language and yr="2020 -Current")	1834
38	(review or letter or note or editorial or conference abstract).pt.	10777658
39	37 not 38	**1399**

Ovid MEDLINE(R) ALL <1946 to September 17, 2024>

1	artificial intelligence/	49110
2	artificial intelligence.tw.	48371
3	machine learning/	43661
4	machine learning.tw.	108997
5	deep learning/	22706
6	deep learning.tw.	61249
7	(AI-powered or AI-driven or AI-enabled).tw.	2098
8	natural language processing/	7140
9	natural language processing.tw.	8387
10	large language model*.tw.	2619
11	transformer*.tw.	9901
12	BERT.tw.	1586
13	GPT*.tw.	7165

14	(T5 not (T5 adj9 (T0 or T4 or T1 or baseline or minutes or hour* or day* or week* or month* or year*))).tw.	3891
15	RoBERTa.tw.	225
16	XLNet.tw.	39
17	ALBERT.tw.	3556
18	BART.tw.	1060
19	DistilBERT.tw.	43
20	GLaM.tw.	49
21	LLaMA.tw.	1410
22	Chatbot.tw.	1287
23	supervised machine learning/	2167
24	unsupervised machine learning/	1008
25	(supervised learning or unsupervised learning).tw.	8189
26	robotics/	29667
27	robot*.tw.	80874
28	or/1-27	336966
29	exp dentistry/	444437
30	(dentistry or dental).tw.	299959
31	(periodont* or endodont* or orthodont* or prosthodont* or "oral surgery").tw.	170752
32	29 or 30 or 31	665011
33	28 and 32	2759
34	limit 33 to (english language and yr="2020 -Current")	2042
35	(editorial or letter or news or "review" or "systematic review").pt.	5691272
36	34 not 35	**1607**

Database - CINAHL Ultimate via EBSCOhost

#	Query	Results
S1	TI "artificial intelligence" OR AB "artificial intelligence" OR SU "artificial intelligence"	18,615
S2	TI "machine learning" OR AB "machine learning" OR SU "machine learning"	17,967

S3	TI "deep learning" OR AB "deep learning" OR SU "deep learning"	8,005
S4	TI (AI-powered or AI-driven or AI-enabled) OR AB (AI-powered or AI-driven or AI-enabled)	423
S5	TI "natural language processing" OR AB "natural language processing" OR SU "natural language processing"	4,514
S6	TI "large language model*" OR AB "large language model*" OR SU "large language model*"	489
S7	TI T5 NOT (T5 N9 (T0 or T4 or T1 or baseline or minutes or hour* or day* or week* or month* or year*)) OR AB T5 NOT (T5 N9 (T0 or T4 or T1 or baseline or minutes or hour* or day* or week* or month* or year*)) OR SU T5 NOT (T5 N9 (T0 or T4 or T1 or baseline or minutes or hour* or day* or week* or month* or year*))	338
S8	TI (BERT or GPT* or RoBERTa or XLNet or ALBERT or BART or DistilBERT or GLaM or LLaMA or chatbot or transformer*) OR AB (BERT or GPT* or RoBERTa or XLNet or ALBERT or BART or DistilBERT or GLaM or LLaMA or chatbot or transformer*) OR SU (BERT or GPT* or RoBERTa or XLNet or ALBERT or BART or DistilBERT or GLaM or LLaMA or chatbot or transformer*)	3,436
S9	TI ("supervised learning" or "unsupervised learning") OR AB ("supervised learning" or "unsupervised learning") OR SU ("supervised learning" or "unsupervised learning")	531
S10	TI (robotics or robot*) OR AB (robotics or robot*) OR SU (robotics or robot*)	20,565
S11	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10	64,902
S12	TI (dental or dentistry) OR AB (dental or dentistry) OR SU (dental or dentistry)	146,429
S13	TI (periodont* or endodont* or orthodont* or prosthodont* or "oral surgery") OR AB (periodont* or endodont* or orthodont* or prosthodont* or "oral surgery") OR SU (periodont* or endodont* or orthodont* or prosthodont* or "oral surgery")	48,098
S14	S12 OR S13	168,697
S15	S11 AND S14	716
S16	S11 AND S14 Limiters - Publication Date: 20200101-20241231; English Language	566
S17	SU (review* or letter* or editorial) OR TI (review* or letter* or editorial) OR AB (review* or letter* or editorial)	986,422
S18	S16 NOT S17	**464**

Database - Dentistry & Oral Sciences Source via EBSCOhost

#	Query	Results
S1	TI "artificial intelligence" OR AB "artificial intelligence" OR SU "artificial intelligence"	1,350
S2	TI "machine learning" OR AB "machine learning" OR SU "machine learning"	562
S3	TI "deep learning" OR AB "deep learning" OR SU "deep learning"	478
S4	TI (AI-powered or AI-driven or AI-enabled) OR AB (AI-powered or AI-driven or AI-enabled)	73
S5	TI "natural language processing" OR AB "natural language processing" OR SU "natural language processing"	43
S6	TI "large language model*" OR AB "large language model*" OR SU "large language model*"	25
S7	TI T5 NOT (T5 N9 (T0 or T4 or T1 or baseline or minutes or hour* or day* or week* or month* or year*)) OR AB T5 NOT (T5 N9 (T0 or T4 or T1 or baseline or minutes or hour* or day* or week* or month* or year*)) OR SU T5 NOT (T5 N9 (T0 or T4 or T1 or baseline or minutes or hour* or day* or week* or month* or year*))	21
S8	TI (BERT or GPT* or RoBERTa or XLNet or ALBERT or BART or DistilBERT or GLaM or LLaMA or chatbot or transformer*) OR AB (BERT or GPT* or RoBERTa or XLNet or ALBERT or BART or DistilBERT or GLaM or LLaMA or chatbot or transformer*) OR SU (BERT or GPT* or RoBERTa or XLNet or ALBERT or BART or DistilBERT or GLaM or LLaMA or chatbot or transformer*)	329
S9	TI ("supervised learning" or "unsupervised learning") OR AB ("supervised learning" or "unsupervised learning") OR SU ("supervised learning" or "unsupervised learning")	25
S10	TI (robotics or robot*) OR AB (robotics or robot*) OR SU (robotics or robot*)	579
S11	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10	2,750
S12	TI (dental or dentistry) OR AB (dental or dentistry) OR SU (dental or dentistry)	296,366
S13	TI (periodont* or endodont* or orthodont* or prosthodont* or "oral surgery") OR AB (periodont* or endodont* or orthodont* or prosthodont* or "oral surgery") OR SU (periodont* or endodont* or orthodont* or prosthodont* or "oral surgery")	126,479
S14	S12 OR S13	349,616
S15	S11 AND S14	1,745
S16	S11 AND S14 Limiters - Publication Date: 20200101-20241231	1,362
S17	SU (review* or letter* or editorial) OR TI (review* or letter* or editorial) OR AB (review* or letter* or editorial)	66,741
S18	S16 NOT S17	**1,130**

Scopus

(TITLE-ABS-KEY ("artificial intelligence" OR "machine learning" OR "deep learning" OR ai-powered OR ai-driven OR ai-enabled OR "natural language processing" OR "large language model*" OR transformer* OR (t5 AND
NOT (t5 W/9 (t0 OR t4 OR t1 OR baseline OR minutes OR hour* OR day* OR week* OR month* OR year*))) OR bert OR gpt* OR roberta OR xlnet OR albert OR bart OR distilbert OR glam OR llama OR chatbot OR "supervised learning" OR "unsupervised learning" OR robot*))

AND

TITLE-ABS-
KEY (dental OR dentistry OR periodont* OR endodont* OR orthodont* OR prosthodont* OR "oral surgery")

AND

PUBYEAR > 2019 AND PUBYEAR < 2025 AND (EXCLUDE (DOCTYPE , "cp") OR EXCLUDE (DOCTYPE , "re") OR EXCLUDE (DOCTYPE , "cr") OR EXCLUDE (DOCTYPE , "ch") OR EXCLUDE (DOCTYPE , "ed") OR EXCLUDE (DOCTYPE , "le") OR EXCLUDE (DOCTYPE , "no") OR EXCLUDE (DOCTYPE , "bk")) AND (LIMIT-TO (LANGUAGE , "English"))

2263

Web of Science

((TS=("artificial intelligence" OR "machine learning" OR "deep learning" OR AI-powered OR AI-driven OR AI-enabled OR "natural language processing" OR "large language model*" OR transformer* OR (T5 NOT (T5 Near/9 (T0 OR T4 OR T1 OR baseline OR minutes OR hour* OR day* OR week* OR month* OR year*))) OR BERT OR GPT* OR RoBERTa OR XLNet OR ALBERT OR BART OR DistilBERT OR GLaM OR LLaMA OR chatbot OR "supervised learning" OR "unsupervised learning" OR robot*)) AND TS=(dental OR dentistry OR periodont* OR endodont* OR orthodont* OR prosthodont* OR "oral surgery")) NOT DT=(Letter OR Note OR Review OR Editorial Material OR meeting abstract OR meeting summary OR proceedings paper) and English (Languages)

1902

IEEEXPlore

((("All Metadata":"artificial intelligence" OR "All Metadata":"machine learning" OR "All Metadata":"deep learning" OR "All Metadata":AI-powered OR "All Metadata":AI-driven OR "All Metadata":AI-enabled OR "All Metadata":"natural language processing" OR "All Metadata":"large language model*" OR "All Metadata":transformer* OR "All Metadata":T5 OR "All Metadata":BERT OR "All Metadata":GPT* OR "All Metadata":RoBERTa OR "All Metadata":XLNet OR "All Metadata":ALBERT OR "All Metadata":BART OR "All Metadata":DistilBERT OR "All Metadata":GLaM OR "All Metadata":LLaMA OR "All Metadata":chatbot OR "All Metadata": "supervised learning" OR "All Metadata":"unsupervised learning" OR "All Metadata":robot*) AND ("All Metadata":dental OR "All Metadata":dentistry OR "All Metadata":periodont* OR "All Metadata":endodont* OR "All

Metadata":orthodont* OR "All Metadata":prosthodont* OR "All Metadata":"oral surgery")) NOT "Document Title":review)

Filter applied: Journals; 2020-2024

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