



Teledentistry in pre-pandemic and post-pandemic dental care: adoption, clinical evidence and unresolved limits

Teleodontología en la atención dental prepandémica y pospandémica: adopción, evidencia clínica y límites no resueltos

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Submitted: 24-03-2023 | Revised: 29-05-2023 | Accepted: 29-09-2023 | Published: 14-10-2023

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ABSTRACT

Teledentistry expanded abruptly when the COVID-19 pandemic suspended face-to-face dental care, but the durability of that expansion and the evidence supporting routine use remain uncertain. This narrative review synthesized the adoption, the clinical evidence and the unresolved limits of teledentistry after the pandemic through four contrasts: the pre-pandemic, pandemic and post-pandemic periods; remote versus in-person examination; synchronous versus asynchronous modalities; and high-income versus low- and middle-income settings. PubMed, OpenAlex and Crossref were searched for literature published between 2015 and 2023, and the material was organized into five thematic axes under the SANRA framework. Interest in teledentistry increased about fivefold during the pandemic and publication volume surged after 2020, yet reported practice remained below stated awareness and post-pandemic persistence depended on policy and reimbursement. For screening and triage, remote assessment approached in-person performance, with sensitivity of 80-88% and specificity of 73-95% in the most comprehensive synthesis and high accuracy for oral lesion detection, but it was less reliable for lesion staging and for conditions requiring palpation or radiographs. Asynchronous capture dominated screening while synchronous video supported real-time decisions, and remote orthodontic monitoring improved plaque control in prospective studies. Adoption lagged in low- and middle-income settings, constrained by infrastructure, cost and connectivity, and regulation, privacy and equity remain unresolved. Teledentistry persisted beyond the acute pandemic as a triage and monitoring tool, complementary to rather than a substitute for in-person examination.

Keywords: teledentistry; telemedicine; dental care; COVID-19; diagnosis; health services accessibility.

RESUMEN

La teleodontología se expandió de forma abrupta cuando la pandemia de COVID-19 suspendió la atención dental presencial, pero la durabilidad de esa expansión y la evidencia que respalda su uso son inciertas. Esta revisión narrativa sintetizó la adopción, la evidencia clínica y los límites no resueltos de la teleodontología tras la pandemia mediante cuatro contrastes: período prepandémico, pandémico y pospandémico; exploración remota frente a presencial; modalidades síncrona y asíncrona; y países de ingresos altos frente a bajos y medios. Se buscó en PubMed, OpenAlex y Crossref literatura de 2015 a 2023, organizada en cinco ejes según SANRA. El interés por la teleodontología aumentó cinco veces durante la pandemia y las publicaciones crecieron después de 2020, aunque la práctica quedó por debajo de la conciencia manifestada y la persistencia dependió de políticas y reembolso. Para el cribado y el triaje, la valoración remota se aproximó al rendimiento presencial, con sensibilidad de 80-88% y especificidad de 73-95% y alta precisión para lesiones orales, aunque resultó menos fiable para la estadificación y para cuadros que requieren palpación o radiografías. La captura asíncrona dominó el cribado mientras el vídeo síncrono apoyó decisiones en tiempo real, y la monitorización ortodóncica remota mejoró el control de placa. La adopción fue menor en los países de ingresos bajos y medios, y la regulación, la privacidad y la equidad siguen sin resolverse. La teleodontología persistió tras la fase aguda como herramienta de triaje y monitorización, complementaria y no sustitutiva de la exploración presencial.

Palabras clave: teleodontología; telemedicina; atención odontológica; COVID-19; diagnóstico; accesibilidad a los servicios de salud.

INTRODUCTION

The COVID-19 pandemic suspended routine dental care on a scale without precedent. Dental procedures generate aerosols, require close face-to-face contact and were among the first services to be restricted during lockdowns, which left triage, consultation and follow-up without an obvious delivery channel.⁽¹⁾ Teledentistry, the application of telecommunication and digital imaging to the delivery of dental care, education and consultation at a distance, became the instrument through which much of this interrupted care was rerouted.^(2,3) It spans triage, remote diagnosis, specialist consultation, treatment monitoring and education, a breadth that makes it more than a single technology and that explains why its evidence is so unevenly distributed.⁽⁴⁾ Before the pandemic the field had existed for decades, mostly as public programmes, school-based screening pilots and remote-area consultations; within weeks of the first lockdowns it moved from the margins to the centre of dental practice.⁽⁵⁾

Two delivery modes carry this practice. Synchronous teledentistry uses live video or telephone to reproduce a consultation in real time, whereas asynchronous teledentistry, also called store-and-forward, collects photographs, radiographs and questionnaire data for review by a dentist at a later time. The distinction determines cost, workflow and the questions that can be answered remotely, and it runs through every evaluation of the field.

The magnitude of that shift is measurable. Search interest in teledentistry increased fivefold during the pandemic, alongside a thirtyfold rise in queries for personal protective equipment for dentists and a fortyfold rise in queries about whether it was safe to visit a dentist.⁽⁶⁾ Bibliometric data describe the same pattern: the published literature surged after 2020, and most of the 369 articles indexed on the topic appeared in the years that followed the first wave.^(7,8) What remains contested is whether this expansion represented durable adoption or an emergency improvisation that receded as clinics reopened. Answering that question requires comparing three periods, the low pre-pandemic baseline, the pandemic surge and the post-pandemic equilibrium, rather than describing each in isolation.

The same comparative logic extends to the other questions that now define the field. The clinical value of teledentistry depends on how remote assessment performs against in-person examination, the reference standard against which diagnostic concordance, triage decisions and treatment planning have been measured.⁽⁹⁾ Its practical organization depends on the modality chosen, synchronous video against asynchronous store-and-forward capture, and on the setting in which it is deployed, high-income against low- and middle-income countries, where infrastructure and workforce differ sharply.^(10,11) Each contrast isolates a different reason why teledentistry might be adopted or abandoned, and why the evidence that supports it in one context does not transfer automatically to another. These contrasts matter for clinical decisions as much as for policy. A clinician deciding whether a photograph can rule out a carious lesion, a health system deciding whether to reimburse a video consultation, and a ministry deciding whether a remote pathway can extend care to a rural population are all asking the same underlying question, whether a remote channel performs the specific job delegated to it. Grouping the evidence by the job it was asked to do, rather than by technology or specialty, is what makes the comparison informative.

The objective of this review was to synthesize, through a comparative lens, the adoption, the clinical evidence and the unresolved limits of teledentistry after the COVID-19 pandemic. Specifically, it sought to compare the scale and durability of adoption before, during and after the acute phase of the pandemic; to compare the clinical evidence, mainly diagnostic concordance and triage, between teledentistry and in-person examination and between synchronous and asynchronous modalities; to compare adoption and barriers between high-income and low- and middle-income countries; and to identify the regulatory, technical, privacy and equity limits that remain unresolved.

METHODS

PubMed, OpenAlex and Crossref were searched for literature on teledentistry, telediagnosis, remote oral examination and related terms, combined with the concepts of adoption, diagnostic accuracy, synchronous and asynchronous delivery, and country income level. The core literature that sustains the synthesis was restricted to the period 2015 to 2023; earlier work was admitted when it supplied a definition, a methodological reference or a classic finding, as allowed for the supporting literature of a narrative review. No claim of exhaustiveness is made, and the review follows the SANRA scale for the quality of narrative review articles rather than systematic review procedures.⁽¹²⁾ Reference lists of included syntheses were scanned for additional primary studies,

and the priority journals of the publishing house were searched for pertinent work; no pertinent in-window item was found there.

Studies were selected when they reported at least one of the following: population or provider estimates of teledentistry adoption or acceptability; diagnostic accuracy or concordance against an in-person examination; synchronous or asynchronous applications; or barriers and facilitators in a defined setting. Priority was given to original studies and to systematic reviews that reported a quantitative synthesis; narrative and integrative reviews were used to frame the evidence rather than to supply primary findings. The selected material was organized into five contrast axes: adoption before, during and after the pandemic; teledentistry versus in-person examination for diagnosis and triage; synchronous versus asynchronous modalities; high-income versus low- and middle-income settings; and unresolved limits. Within each axis, converging and diverging findings were weighed together with the design and quality of the source studies. Selected studies were logged in a working matrix that maps each axis to the claims it supports and to the studies that support or contradict them, so that the direction and the weight of the evidence behind each statement remain traceable to the bibliography.

Because definitions of teledentistry, outcome measures and reference standards vary across studies, only findings that used an explicit in-person comparator or a stated population denominator were treated as quantitative. The synthesis of the axes is summarized in (Table 1).

Table 1. Synthesis of the teledentistry evidence by contrast axis.

Contrast axis	Compared contexts	Key findings	Representative studies
Adoption	Pre-pandemic vs pandemic vs post-pandemic	Marginal baseline; fivefold interest surge during the pandemic; practice lagged behind awareness; persistence conditional on policy and reimbursement	Sycinska-Dziarnowska et al., 2021; Valeri et al., 2023; Kui et al., 2022; Tantawi et al., 2023
Remote vs in-person diagnosis	Teledentistry vs clinical examination	Sensitivity 80-88% and specificity 73-95% for referral and diagnosis; high accuracy for oral lesions; less reliable for staging and palpation-dependent conditions	Gurgel-Juarez et al., 2022; Uhrin et al., 2023; Estai et al., 2016
Modality	Synchronous vs asynchronous	Asynchronous capture dominates screening and monitoring; synchronous video supports real-time decisions; comparable patient experience, practitioner preference for in-person	Charavet et al., 2023; Sangalli et al., 2021; Allen et al., 2020
Setting	High-income vs low- and middle-income	High-income scale-up through policy and reimbursement; low- and middle-income settings constrained by infrastructure, cost and connectivity	Howell et al., 2023; Mahmoud et al., 2022; Fahim et al., 2022
Unresolved limits	Regulation, privacy, equity	Fragmented regulation and reimbursement; unsettled data protection; digital divide reproduces access gaps; favourable but narrow cost evidence	Semprini et al., 2023; Di Fede et al., 2023; Estai et al., 2018

Note: The axes correspond to the comparative structure of the review. Representative studies are cited by first author and year. Source: Elaboration based on the studies selected in this review.

DEVELOPMENT

The synthesis is organized in five axes, each built on a contrast that separates a condition under which teledentistry succeeds from one under which it does not.

Adoption before, during and after the pandemic

Before 2020 teledentistry was real but marginal. Early programmes were anchored in school dental screening, remote-area care and the first virtual dental home models, which demonstrated feasibility and cost savings without becoming the default pathway of care.^(13,14) An integrative review of public dental services published at the end of the decade found teledentistry applied mainly to screening, education and specialist consultation, and national reports such as that for Chile described pilot projects rather than sustained services.^(2,15) The pandemic compressed years of slow diffusion into months. Public search interest in teledentistry multiplied fivefold, and the bibliometric record shows the same inflection: of the publications captured in one bibliometric

analysis, the large majority accumulated after 2020, and an integrative review found that 43 of 52 relevant papers appeared after that year.(6,7,16) Implementation, however, was improvised and uneven. A scoping review of pandemic-era implementation identified asynchronous triage and remote prescribing as the dominant uses, and single-centre accounts describe platforms assembled within days to keep clinics functioning during lockdown.(5,17)

Professional adoption followed awareness rather than the reverse. Surveys in Saudi Arabia, Malaysia and Indonesia reported substantial awareness and favourable attitudes but a lower proportion of respondents who actually used teledentistry in their practice.(18-20) A systematic review with meta-analysis of practitioner perceptions reached the same conclusion, and a national survey of 2,767 providers in the United States found that perceived value exceeded routine use.(21,22) In Ontario, a survey of 456 dentists during the pandemic found that clinician use remained suboptimal despite reported benefits, with uptake associated with practice location and professional characteristics.(23) Patient-facing demand was more consistent: a patient survey reported satisfaction of 97% and 94% with virtual-clinic and telephone consultations respectively, and satisfaction studies in oral medicine and a systematic review of rural and remote e-oral health reached similar conclusions.(24-27) Acceptability extended to underserved groups, including rural adults in the United States who valued the removal of travel barriers.(28)

Geographically, the surge was general but not uniform. Global accounts of the pandemic period describe teledentistry operating across Europe, the Americas, Asia and the Middle East, with the strongest documented programmes where public systems already had telehealth infrastructure, as in Brazil and Canada.(29-31) Paediatric dentistry was an early adopter, because remote screening fits the school and community settings in which children are reached, and dedicated reviews position teledentistry as a permanent complement to paediatric practice rather than a pandemic expedient.(32-34)

What happened after the acute phase is the least documented and the most consequential. The integrative reviews that asked the question directly conclude that attitudes improved and that teledentistry will persist, but that persistence is conditional.(16,35) A nineteen-country account found that only five countries had telehealth policies, and fewer had developed teledentistry-specific guidelines, even though most reported some form of pandemic-era service.(10) In Canada, almost all jurisdictions promoted teledentistry for triage, but fewer than half had issued guidance on modalities, privacy, consent or standards of practice.(31) Australia showed the same pattern: a scoping review identified a surge paralleling the pandemic but limited evidence of consolidated delivery models.(36) Adoption therefore persisted where regulation and reimbursement followed, and thinned where the emergency measures were not converted into standing policy.(37) Consumer-level data from the first months of the pandemic show that teledentistry use tracked pandemic concern rather than clinical need, and that the billable scope of remote visits, not patient interest, was the binding constraint once in-person care resumed.(38)

Teledentistry versus in-person examination for diagnosis and triage

The most complete synthesis of diagnostic performance is a systematic review of systematic reviews that pooled six reviews covering more than 7,000 participants; it reported sensitivity between 80% and 88% and specificity between 73% and 95% for dental referrals and diagnostic treatment planning, while noting that the underlying reviews were of low quality.(9) Caries detection has the longest evidence trail. Early systematic reviews concluded that teledentistry performed comparably to non-telemedicine alternatives, with the caveat that methodological quality was limited.(39,40) Field studies quantify that comparability: a smartphone photographic method achieved moderate sensitivity of 60% to 63% with almost perfect intra-grader agreement (κ 0.84) against face-to-face assessment, and a school-based comparison found mean caries scores of 3.42 and 3.17 for dental and non-dental photography against 3.38 on clinical examination.(41,42) Recent meta-analyses of caries scores and of visual examination against electronic check-up in children confirm comparable performance, and intraoral cameras extend the same result to screening in prisons.(43-46)

For oral mucosal lesions, remote assessment is accurate for detection but less so for definitive diagnosis. A diagnostic meta-analysis reported pooled sensitivity of 0.93 (95% CI 0.17 to 1.00) and specificity of 0.92 (95% CI 0.59 to 0.99) for the detection of oral lesions by telediagnosis, with the wide confidence intervals reflecting heterogeneity.(47) Institutional experience in oral and maxillofacial pathology and mobile screening for oral cancer in low-resource settings point in the same direction: remote review is sufficient to triage and refer, while biopsy and specialist examination remain necessary for final diagnosis.(4,48-50) A retrospective series in oral medicine found telemedicine

useful for symptom management during service restrictions.(51)

Two refinements to plain photography raise accuracy. Intraoral scanners captured in approximate true colour allowed remote scoring of dental and periodontal conditions with levels of agreement approaching those of clinical examination.(52) Fluorescence-aided video, evaluated in a two-centre concordance study, supported telediagnosis of caries with a protocol built on the International Caries Detection and Assessment System.(53) Both refinements matter because they standardize the capture step, the variable on which remote caries assessment most depends. In paediatric and special populations, remote screening is feasible and acceptable: a parent-operated app with asynchronous review identified early childhood caries in preschoolers, a double-blind trial in children aged six to twelve years compared mobile diagnosis with expert treatment planning, and teledentistry was judged a feasible alternative for people with special care needs.(54-56) Older adults in nursing homes were among the first populations studied, with the Tel-e-dent study validating remote examination against direct examination as the reference standard.(57,58)

In addition to single-disease accuracy, the practical question is whether remote assessment supports the decisions that follow it. School-based programmes established this use early: teledentistry-based screening identified early childhood caries in school settings, and mid-level providers using a mobile model screened caries with validity comparable to that of dentists, which supports delegating image capture to non-dentists.(59-61) The same logic extends to resource allocation, because screening low-risk schoolchildren remotely was estimated to free conventional screening capacity for higher-risk groups.(14) A randomised controlled trial protocol subsequently designed to test whether a teledentistry pathway improves child oral health outcomes illustrates where the field was heading when the pandemic interrupted it.(62) Treatment planning is more demanding than screening, and the evidence is thinner there: mobile teledentistry showed acceptable reliability for diagnosis and treatment planning in mixed dentition, while reporting lower agreement for the restorative detail that a plan ultimately requires.(63)

The clinical ceiling is equally clear. A single-centre randomised controlled trial reported agreement of 74.3% between teledentistry and clinical records for the chief complaint and for the count of missing teeth, with lower agreement for oral hygiene status, and surgical follow-up studies found teledentistry effective for post-operative review of selected cases.(64,65) (Table 2) collects the quantitative anchors of this axis. Taken together, the evidence positions teledentistry as strong for triage, screening and follow-up and weaker for staging, for interproximal caries and for any condition that depends on palpation, percussion or radiographs.(9,39)

Table 2. Selected studies reporting quantified outcomes of teledentistry compared with in-person care.

Study	Setting and population	Modality	Outcome	Main result
Uhrin et al., 2023	Oral lesions, meta-analysis of 9 studies	Telediagnosis vs clinical examination	Detection of oral lesions	Sensitivity 0.93 (95% CI 0.17-1.00); specificity 0.92 (95% CI 0.59-0.99)
Gurgel-Juarez et al., 2022	Children and adults, 6 systematic reviews, >7,000 participants	Asynchronous and synchronous	Referral and diagnostic treatment planning	Sensitivity 80-88%; specificity 73-95%
Estai et al., 2017	100 adults attending clinics	Smartphone photography, store-and-forward	Caries screening vs face-to-face	Sensitivity 60-63%; weighted kappa 0.84
AlShaya et al., 2022	Schoolchildren aged 5-10 years	Dental and non-dental photography	Caries detection	Mean DMFT 3.38 (clinical), 3.42 (dental), 3.17 (non-dental)
Aboalshamat et al., 2022	70 adults, RCT	Teledentistry vs clinical records	Accuracy of diagnosis	74.3% agreement for chief complaint and missing teeth
Charavet et al., 2023	60 orthodontic patients, RCT	Video teleconsultation vs face-to-face	Patient and practitioner experience	Patient satisfaction comparable ($p = 0.23$); practitioner satisfaction higher in person ($p < 0.01$)
Sangalli et al., 2021	30 orthodontic patients	Remote digital monitoring	Plaque control	Improved plaque index at 3 months ($p = 0.010$) and 6 months ($p = 0.039$)
Torres et al., 2023	Orthodontic patients, 4 studies	Dental Monitoring software	Treatment evolution	Favourable outcomes with very low certainty of evidence

Note: CI = confidence interval; DMFT = decayed, missing and filled teeth; RCT = randomized controlled trial; p = p value. Source: Elaboration based on the studies selected in this review.

Synchronous versus asynchronous modalities

Asynchronous, store-and-forward capture is the workhorse of teledentistry, and the evidence reflects that dominance. The systematic review of systematic reviews found that asynchronous communication supplied most diagnostic and screening outcomes, while synchronous communication was reserved for treatment decisions.⁽⁹⁾ Smartphone and intraoral-camera protocols that transmit photographs for later review are the canonical asynchronous design, from school screening to the WhatsApp-based referral of oral and maxillofacial pathology in Senegal.^(41,50) In orthodontics, asynchronous remote monitoring has moved furthest toward routine use: smartphone-based monitoring applications and the Dental Monitoring system achieved high accuracy for tracking tooth movement, and a prospective study found that remotely monitored patients improved plaque control significantly at three and six months compared with controls.⁽⁶⁶⁻⁶⁸⁾ A systematic review with meta-analysis judged teledentistry favourable for monitoring aligner treatment while rating the certainty of evidence as very low.⁽⁶⁹⁾ Text-message reminders improved oral hygiene in a randomised controlled trial, and remote monitoring reduced the burden of in-office visits without worsening oral health.⁽⁷⁰⁻⁷²⁾

Synchronous video consultation is less studied but answers a different question, whether a live encounter can substitute for the first visit. Guidance for patient-centred communication during synchronous teledentistry emerged early in the pandemic.⁽⁷³⁾ The strongest comparative evidence is a randomised controlled trial of a first orthodontic consultation delivered by video against face-to-face: patients reported comparable satisfaction, communication and sense of privacy, while practitioners rated the in-person encounter significantly more highly.⁽⁷⁴⁾ Provider and patient perspectives on teleorthodontics during and beyond the pandemic converge on the same asymmetry, acceptance by patients and caution by clinicians.⁽⁷⁵⁾ The question the field has not resolved is whether that asymmetry fades once the diagnostic first visit has been completed in person and only follow-up moves online. Direct head-to-head trials of synchronous against asynchronous teledentistry for the same clinical question remain scarce, and modality choice in practice is still driven by case complexity and the technology available rather than by comparative evidence.

Artificial intelligence is beginning to blur the boundary between the two modalities. Asynchronous capture generates the image, and algorithms can then detect caries in mobile photographs with performance approaching human grading, which would make store-and-forward screening less dependent on a live reviewer.⁽⁷⁶⁾ Remote monitoring platforms already embed this logic, using algorithmic analysis of patient-captured scans to flag problems between appointments.^(66,67) Synchronous care, by contrast, has no algorithmic shortcut for the clinical judgement it supports, which is one reason its evidence remains anchored to communication rather than to accuracy.⁽⁷³⁾

High-income versus low- and middle-income settings

The pandemic scaled teledentistry in high-income settings through policy, reimbursement and organized delivery models. In the United States, teledentistry adoption was framed around virtual dental homes that connect allied dental providers to remote supervision, and pandemic-era policy changes temporarily expanded the billable scope of remote visits.^(34,37) Consumer use rose with pandemic concern, and provider surveys documented the shift from emergency triage toward broader applications.^(22,23,38) Canada and Australia followed similar trajectories, with national and provincial bodies endorsing triage use while guidelines lagged behind practice.^(31,36)

Low- and middle-income countries experienced the same incentive to adopt but far tighter constraints. Scoping reviews of telemedicine in low- and middle-income countries during the pandemic describe feasibility alongside shortages of connectivity, devices and trained personnel.^(11,77) Dental-specific reports make the constraint concrete: dentists in Pakistan described personnel, technological and organizational barriers as the dominant challenges, while Indonesia, Senegal, Fiji and Brazil operated teledentistry through consumer platforms such as WhatsApp and through public telehealth networks rather than dedicated infrastructure.^(30,50,78-80) Rural India and South Africa illustrate the older rationale for teledentistry in these settings, extending scarce professional capacity to underserved populations.^(81,82) The barriers themselves are shared across income levels, but their intensity is not: a systematic review of digital health adoption among health professionals found the same themes of usability, workload and interoperability reported everywhere, amplified in settings with weaker infrastructure.⁽⁸³⁾ Qualitative work unpacks those categories: dentists in Pakistan, interviewed through a technology-organization-environment lens, identified personnel readiness, technological reliability and organizational support as distinct failure points, each requiring a different mitigation.⁽⁷⁸⁾ Separating them matters because it distinguishes problems that training can solve from problems that require investment or policy. Low-cost consumer platforms

act as the compensating facilitator, which is why adoption in low- and middle-income countries is real but fragile and unevenly distributed.

Public networks illustrate the middle path between dedicated infrastructure and consumer improvisation. The Telehealth Brazil Networks Programme integrated dental teleconsultation into primary care, where remote sessions changed the conduct of oral health teams and avoided a measurable share of referrals, and Indonesian primary health centres paired teledentistry with online referral during the pandemic.(30,79) Chile had described the same ambition before the pandemic, a national teledentistry strategy constrained by geography rather than by need.(15) India framed teledentistry as public infrastructure for a population living beyond the reach of the dental workforce, a model the pandemic validated rather than created.(81,82) These programmes share a feature that distinguishes them from the high-income virtual dental home: they extend the reach of an existing public workforce rather than add a reimbursed private channel.(13,34)

Unresolved limits

Regulation and reimbursement remain the most consequential unresolved limit. A scoping review of three decades of Medicaid dental policy found variation that conditions whether remote care is available at all, and the nineteen-country account showed that telehealth policies exist in a minority of the settings that now use teledentistry.(10,84) Jurisdictional analyses reach the same conclusion: Canadian guidance on consent, privacy and standards of practice covered fewer than half of the jurisdictions that promoted teledentistry, and medicolegal analyses in India and Indonesia document practitioners practising without clear legal cover.(31,85,86) Privacy and data protection are no more settled. A scoping review of patient data protection in digital oral health care found that image sharing and commercial platforms sit unevenly within existing regulation, and privacy-preservation remains an open design problem for telemedicine generally.(87,88) An appraisal of teledentistry applications available on consumer stores raises the same concern from the product side.(89) Consent and standards of practice are the quiet part of the same gap: analyses of medicolegal exposure in India and of practitioners' legal knowledge in Indonesia find that remote care proceeds without settled rules on who may review an image, how records are stored or how liability is apportioned.(85,86)

The diagnostic limits described above are also unresolved limits of the field. The most comprehensive synthesis is built on systematic reviews of low quality, the caries literature is dominated by small studies with limited methodological rigour, and the wide confidence intervals around oral lesion detection reflect heterogeneity rather than precision.(9,39,47) Conditions that require palpation, percussion or radiographs have no validated remote equivalent, which bounds the legitimate scope of teledentistry.(43) Equity cuts across the other limits. The digital divide documented for telehealth during the pandemic, in which older, rural and low-income groups were least able to use the new channels, applies with equal force to dentistry, where acceptability surveys show that travel removal is valued precisely by the populations with the least digital access.(28) Teledentistry for older adults and for special-care patients is feasible, but its benefit depends on exactly the groups most exposed to that divide.(56,58) Cost evidence is favourable but narrow: school screening models save resources, a scoping review of telehealth economics found potential savings that depend on context, and the evidence base beyond screening is thin.(14,90) Artificial intelligence, illustrated by deep-learning detection of caries in mobile photographs, promises to extend asynchronous screening, but it adds a further layer of validation and governance that has not yet been resolved.(62,76)

A further unresolved limit is the workforce itself. Surveys that measure awareness alongside practice consistently find a training gap: practitioners know teledentistry exists but have not been taught to capture diagnostic images, to set triage criteria or to document remote encounters in a defensible way.(19,21) Standards for image acquisition, such as the intraoral photography recommendations developed for monitoring mucosal lesions, exist but are not yet part of routine training.(4) Until capture and triage are taught as clinical competencies, the accuracy reported in research settings will not reliably reproduce in everyday practice.

DISCUSSION

The central finding of this synthesis is that teledentistry survived the acute phase of the pandemic, but as a complementary layer of triage, screening and monitoring rather than as a substitute for the chairside examination. The adoption evidence, the diagnostic evidence and the unresolved limits all point in the same direction: teledentistry is strongest exactly where an in-per-

son visit is least informative or least accessible, and weakest where the physical examination is the deciding input. That is why persistence after the pandemic is partial and conditional, and why the field has consolidated around asynchronous screening and remote monitoring rather than around a general remote practice.

This reading converges with the systematic syntheses available. The review of systematic reviews that anchors the diagnostic evidence reported accuracy that is good enough for referral and treatment planning but drawn from low-quality reviews, which is precisely the mixed picture described here.⁽⁹⁾ Earlier validity reviews reached the same verdict of comparable but underpowered evidence.^(39,40) On adoption, the reviews are more optimistic than the data they summarize: integrative reviews conclude that attitudes improved and that use will continue to rise, whereas the surveys and policy analyses assembled here show a gap between awareness and practice and a persistence that follows regulation and reimbursement rather than enthusiasm.^(3,10,16,23,35) The difference is mostly one of emphasis. Reviews that weigh provider attitudes conclude optimism; those that weigh reimbursement, licensure and infrastructure conclude conditionality, and both readings can be true of the same period.

The contrast with telemedicine outside dentistry is instructive. In primary care, the pandemic produced a documented substitution of telehealth for in-person visits, followed by a partial reversion as clinics reopened, with equity effects concentrated in older, rural and low-income populations.⁽⁹¹⁻⁹³⁾ Dentistry shows the same arc but a shallower plateau, because a larger share of dental work depends on operative procedures that no remote channel can perform.^(94,95) Where capture can be standardized, telemedicine achieves diagnostic accuracy that teledentistry has not yet matched: systematic reviews of diabetic retinopathy screening and of surgical site infection report high and reproducible accuracy because the image, the lesion and the grading rule are all standardized.^(96,97) The intraoral photograph is less standardized, which explains why caries sensitivity in field studies sits at the moderate 60% to 63% while agreement within a single grader is almost perfect.⁽⁴¹⁾ Standardization of image acquisition, not the diagnostic concept, is the main technical difference between teledentistry and the telemedicine specialties that have succeeded.

The synchronous and asynchronous contrast explains a second divergence, the one between patients and clinicians. In the single randomised controlled trial of a first remote orthodontic consultation, patients and practitioners diverged: patients found the remote encounter comparable, practitioners preferred the in-person one.⁽⁷⁴⁾ The same asymmetry appears across teleorthodontics.⁽⁷⁵⁾ Clinicians carry the diagnostic and medicolegal risk, and until that risk is defined, their caution is rational rather than merely conservative.^(85,86) Patients, who experience the convenience and the avoided travel, respond to a different calculus.^(27,98) This is a reminder that adoption data in this field are mostly cross-sectional and self-reported, and they support statements about association and perception, not about effectiveness or causation.⁽⁸³⁾

The setting contrast carries the same caution across countries. High-income systems scaled teledentistry when policy and reimbursement moved, as the virtual dental home and Canadian and Australian experiences show.^(31,34,36) Low- and middle-income systems adopted through consumer platforms and public telehealth networks with thinner infrastructure, which makes their adoption real but fragile.^(11,77,78,82) The barriers are the same themes reported everywhere, workload, interoperability, usability and cost, but their severity scales inversely with resources.⁽⁸³⁾ Equity is therefore not a side effect of teledentistry but a structural property of it: the digital divide that telehealth reproduced during the pandemic applies with equal force to dentistry, and the populations that stand to gain most from remote care, older, rural and low-income groups, are the ones least equipped to use it.^(93,99,100)

Several strengths support these conclusions. The review assembled evidence from three bibliographic sources across a defined window, applied explicit selection criteria, and treated as quantitative only findings with an in-person comparator or a stated denominator, which limits the risk of over-reading anecdotal reports. The comparative structure forced each claim to be weighed against its opposite, surfacing the divergences between patient and provider, between screening and definitive diagnosis, and between high- and low-resource settings that a purely thematic account would flatten. Two interpretative cautions apply throughout. Most adoption studies are cross-sectional surveys and most accuracy studies are single-centre convenience samples, so the associations reported here describe perceptions and performance under research conditions rather than effectiveness in routine care.^(39,83) No finding in this review licenses a causal reading of the pandemic as the cause of adoption or of teledentistry as the cause of any oral health outcome.⁽²¹⁾

The review has limitations that follow from its design. It is narrative rather than systematic, so selection and publication bias toward positive accuracy studies cannot be excluded; a preregistered living systematic review with multilingual search and grey literature would address this. Only three

databases and, in practice, mainly English and Spanish records were used, which under-represents non-Western implementation; a multilingual strategy would capture more of the low- and middle-income experience. The heterogeneity of definitions, capture protocols and reference standards prevented any pooling of the accuracy data, so the quantitative anchors cited here are illustrative rather than pooled estimates; standardized reporting for teledentistry diagnostic studies, analogous to STARD, would make future syntheses possible. Most studies measure accuracy and acceptability, not the post-pandemic outcomes that matter for policy, such as reimbursement-driven utilization, avoidable referrals or oral health consequences; claims-based and implementation studies are needed to fill that gap. Finally, many primary studies are small and of low methodological quality, as the systematic reviews themselves note;(9,39) larger multicentre diagnostic studies would raise the certainty of the field.

The practical implications are concrete. Clinically, teledentistry should be positioned for triage, screening, post-operative follow-up and orthodontic monitoring, and not for the definitive diagnosis of conditions that require palpation, percussion or radiographs. Organizationally, asynchronous store-and-forward is the default for screening and monitoring, with synchronous video reserved for decisions that require a live exchange, a division already reflected in the evidence.(9)For policy, the conditionality of adoption argues for converting emergency measures into standing rules on reimbursement, licensure, consent and data protection, since those are the variables that predict whether teledentistry persists.(10,84,87)For education, the gap between awareness and practice suggests that training should emphasize image capture, triage criteria and the legal boundaries of remote care, not the technology itself.(101)

The primary-care experience adds two lessons that transfer to dentistry. First, the transition to telehealth was sustained only where workflows, scheduling and documentation were redesigned around the new channel rather than bolted onto existing routines, a finding consistent across primary care clinics during the first wave.(102,103) Second, patient satisfaction with remote encounters has been high for decades, which means satisfaction alone cannot discriminate between a good substitute and a convenient one.(98)Both lessons reinforce the caution that adoption and acceptability are necessary but not sufficient evidence for replacing the chairside.

Training deserves separate emphasis because it is the cheapest lever and the least used. The divergence between clinician caution and patient acceptance is partly a training problem: clinicians who are not confident in the triage criteria and the legal boundaries of remote care will rationally default to the chairside.(74,85) Structured curricula that teach image capture, referral criteria and documentation would convert the awareness that surveys already record into the practice they do not.(21)Remote orthodontic monitoring shows what this conversion looks like when it works, a defined capture protocol, an algorithmic check and a clinical review applied to a question narrow enough to be answered remotely.(67,69)

A secondary benefit aligns with the sustainability agenda of dental practice: telemedicine can reduce the carbon footprint of care by replacing patient travel, an effect documented for telehealth broadly and plausible for dental triage and monitoring in particular.(104)The research agenda that follows is equally specific. Head-to-head trials of synchronous against asynchronous teledentistry for the same clinical question are scarce and should be prioritized, alongside economic evaluations that move beyond school screening and artificial-intelligence-assisted screening with defined governance.(62,76,90)Implementation studies in low- and middle-income settings should test whether low-cost consumer platforms can be converted into governed services without losing their reach.(105,106) Until those questions are answered, the responsible summary is that teledentistry persisted after COVID-19 because it solved a triage and monitoring problem, and it will earn a larger role only where its limits are recognized and regulated.

CONCLUSIONS

Teledentistry expanded from a marginal pre-pandemic practice to a pandemic-era surge and then settled into a partial post-pandemic persistence that is conditional on regulation and reimbursement. Remote assessment approaches in-person performance for triage, screening and oral lesion detection, but it remains less reliable for lesion staging and for conditions that require palpation, percussion or radiographs. Asynchronous store-and-forward dominates screening and monitoring, synchronous video supports real-time decisions, and the two modalities have rarely been compared directly. Adoption is real but fragile in low- and middle-income settings, where infrastructure, cost and connectivity concentrate the same barriers seen everywhere. Regulation, privacy, equity and the quality of the diagnostic evidence remain unresolved, and their resolution

will determine whether teledentistry consolidates as a complement to the chairside examination or recedes with the emergency that launched it.

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FUNDING

No financing

CONFLICT OF INTEREST

None

AUTHORSHIP CONTRIBUTIONS

Drafting – original draft: Ana Rodríguez Yanes.
Writing–review and editing: Ana Rodríguez Yanes.