YARSI Dental Journal
UNIVERSITAS YARSI FAKULTAS KEDOKTERAN GIGI
A Scientific Journal Published by Faculty of Dentistry Universitas YARSI

SYSTEMATIC REVIEW

# Accuracy and Early Implementation of Dental Clinical Decision Support Systems in Indonesia for Caries and Periodontal Disease

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**Abstract**
**Introduction:** Clinical decision support systems (CDSS) developed in Indonesia for caries and periodontal risk assessment show diagnostic performance comparable with conventional practice. Reporting is heterogeneous, and implementation evidence remains limited.
**Objective:** To synthesize diagnostic accuracy, comparative performance, and early implementation outcomes of Indonesian dental CDSS for caries and periodontal assessment.
**Methods:** We searched Semantic Scholar via Elicit (initial retrieval = 498 records). We screened studies that (i) developed or validated a CDSS using Indonesian patient data, (ii) compared performance with conventional or expert evaluation, and (iii) reported diagnostic accuracy or implementation outcomes. Extracted items included study design, CDSS type, validation approach, and quantitative outcomes (e.g., sensitivity, specificity, accuracy, odds ratios, user acceptance). **Review/Discussion:** For caries detection, sensitivity ranged from 81.3% to 96.3% and specificity from 92% to 100%; reported accuracies spanned 82.7% to 100%. Approaches included MobileNet-v3/U-net, Naive Bayes, Dempster–Shafer, fuzzy logic, case-based reasoning, and bespoke tools (e.g., SKOR GIGI; Pediatric Caries Predictor). For periodontal assessment, accuracies were 90–96%; a randomized trial showed higher odds of correct staging (OR 4.43, $p = 0.001$) and grading (OR 30.30, $p < 0.001$) versus conventional evaluation; an NLP (BERT) pipeline outperformed a multilayer perceptron for staging/grade classification. Early implementations (web tools, school screening) indicated improved detection/coverage, better oral-health indices, high parent awareness (96%), and user satisfaction (~88%). **Conclusion:** In Indonesian settings, dental CDSS can match or exceed conventional diagnostic accuracy and support treatment recommendations; however, generalizability remains limited by small samples, incomplete reporting, and scarce pragmatic evaluations. To turn these promising signals into routine practice, future work should emphasize multi-site pragmatic studies with standardized reporting of sensitivity, specificity, and predictive values, while concurrently assessing usability and workflow integration to guide scalable adoption.

**Keywords:** Clinical Decision Support Systems, Dental Caries, Indonesia, Periodontal Diseases, Risk Assessment

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## INTRODUCTION

Dental caries and periodontal disease remain pervasive in everyday practice. Although prevention and treatment are well established, the accuracy and consistency of diagnosis and risk stratification still vary across facilities and among clinicians[1]. This variability can delay timely care, complicate treatment planning, and limit opportunities for prevention[1]. In response, clinical decision support systems (CDSS) are being explored to improve the reliability of clinical judgments and to align routine decisions with best practices. In Indonesia, particular interest has grown in CDSS developed with local patient data so that outputs reflect population characteristics and fit existing workflows[2].

Building on this context, the present review focuses on Indonesian dental CDSS for caries and periodontal care. We ask whether systems developed and validated on Indonesian data can match or improve upon conventional or expert evaluations in routine practice[3,4]. A broad literature search was undertaken and a targeted screening was applied; full details of the search strategy and inclusion criteria are provided in the Methods.

The purpose of this paper is to provide a structured narrative synthesis of Indonesian-developed dental CDSS for the assessment and management of caries and periodontal disease. Specifically, we (i) describe how systems have been designed and validated in local contexts, (ii) appraise their diagnostic performance against conventional practice, and (iii) summarize early signals on implementation and user acceptance in settings where these systems have been piloted. Beyond reporting performance metrics, we aim to situate them within the methodological choices that produced them, thereby guiding interpretation and identifying priorities for future research and deployment.

Contributions of this paper

1. Landscape synthesis. We map Indonesian dental CDSS across knowledge-based and machine-learning approaches, relating design choices to intended clinical tasks (screening, risk stratification, staging/grading).
2. Performance context. We interpret reported accuracy in light of study design, reference standards, sampling, and evaluation settings, clarifying where cross-study comparability is strong or limited.
3. Cross-cutting limitations. We highlight recurrent gaps—uneven reporting, constraints on external validity, and scarce pragmatic evaluations—that temper generalizability to routine practice.
4. Practical priorities. We outline near-term directions for Indonesia, emphasizing prospective/pragmatic evaluation, standardized reporting, and attention to implementation factors such as workflow fit, training needs, and user acceptance.

## METHODS

### Information sources and search strategy

We conducted a narrative review focused on Indonesian clinical decision support systems (CDSS) for dental caries and periodontal care. Searches were performed in the Semantic Scholar corpus via Elicit, with an initial retrieval of n = 498 candidate records aligned to our review question. Queries combined free-text terms for clinical decision support, dentistry, caries/periodontal, and Indonesia. No date limits were imposed, English and Indonesian items were eligible, and duplicates were removed prior to screening.

**Eligibility criteria**
Studies were eligible when they met all of the following:

1. Population/Intervention: Indonesian dental patients and a CDSS addressing caries and/or periodontal diagnosis/risk.

2. Comparator: explicit comparison with conventional clinical practice or expert evaluation.
3. Development: CDSS developed and/or validated using Indonesian patient data.
4. Design: randomized or quasi-experimental studies, diagnostic-accuracy studies, or systematic reviews/meta-analyses of these designs.
5. Outcomes: at least one diagnostic metric (e.g., sensitivity, specificity, PPV, NPV) or implementation-related outcome (e.g., appropriateness of recommendations, decision time, diagnostic/planning error).
6. Clinical validation: evidence beyond purely technical development.

**Study selection**
Titles/abstracts from the 498 records were screened against the criteria above. Potentially relevant items underwent full-text review. Two reviewers worked independently to make inclusion decisions, resolving disagreements by discussion.

**Data extraction and quality control**
We used an LLM-assisted template to draft extraction tables (study design; CDSS type and development details, including data sources/algorithms; participant characteristics; diagnostic metrics; comparator tools; and any reported implementation descriptors). All extracted fields were verified by human reviewers against the source PDFs, with corrections applied where discrepancies were identified. A second reviewer re-checked a random subset and any ambiguous items, and consensus adjudication was used to finalize entries.

**Outcomes**
Primary outcomes were diagnostic performance (sensitivity, specificity, PPV, NPV; and, where available, accuracy, precision, recall, F1) and comparative performance versus conventional/expert assessment. Secondary outcomes included appropriateness of treatment recommendations and decision-making time.

**Synthesis approach**
Given heterogeneity in study designs, clinical focus (caries vs periodontal), algorithms, and reporting practices, we used descriptive synthesis. We tabulated study characteristics and summarized performance without quantitative pooling. The decision not to meta-analyze was reinforced by small sample sizes and incomplete reporting of key metrics across several studies.

**Limitations of the method**
Findings are constrained by variability in reporting and the scarcity of large prospective or pragmatic trials, which limits generalizability and precluded formal risk-of-bias stratification and quantitative pooling.

**RESULTS**

**Characteristics of Included Studies**
The synthesized evidence base demonstrates substantial diversity in both study designs and the technologies employed. The majority of the studies utilized diagnostic accuracy designs, while others included a randomized controlled trial (RCT), quasi-experimental

studies, retrospective and prospective cohorts, cross-sectional studies, and system development/validation reports.
The clinical focus of the studies was predominantly on dental caries and caries risk, followed by periodontal conditions. A smaller subset of studies addressed general risk classification, broader oral health conditions, and teacher-led screening initiatives. The spectrum of CDSS evaluated encompassed various computational approaches, ranging from knowledge-based systems (e.g., Naive Bayes, Dempster–Shafer) and decision trees (ID3) to case-based reasoning, machine learning algorithms (SVM/K-NN, NLP BERT/MLP), and image-based AI (MobileNet-v3/U-net). The review also included bespoke devices, applications, and websites developed for specific clinical purposes (SKOR GIGI, Pediatric Caries Predictor, IDCRA).

Validation methods varied significantly across the studies. These methods included comparison against expert or gold-standard evaluations, dataset splitting and cross-validation, pre-post designs, and randomized controlled trials. Some reports also exclusively relied on validation based on reported accuracy metrics or user satisfaction.

**Table 1.** Summary of study characteristics (counts by category)

| Dimension | Category | Count |
|---|---|---|
| Design | Diagnostic accuracy | 16 |
| | Cross-sectional | 2 |
| | System development/validation | 2 |
| | Randomized controlled trial (RCT) | 1 |
| | Quasi-experimental | 1 |
| | Retrospective cohort | 1 |
| | Prospective | 1 |
| Clinical focus | Caries/caries risk | 8 |
| | Periodontal/periodontitis | 5 |
| | Risk classification | 1 |
| | General oral conditions | 1 |
| | Teacher-led screening | 1 |
| CDSS type | Naive Bayes | 3 |

| | | |
|---|---|---|
| | Dempster–Shafer | 3 |
| | Certainty Factor | 3 |
| | Fuzzy (Mamdani/Tsukamoto) | 2 |
| | ID3 | 1 |
| | CBR/Sorgenfrei | 1 |
| | SVM + K-NN | 1 |
| | NLP BERT + MLP | 1 |
| | AHP-SAW | 1 |
| | Image AI (MobileNet-v3/U-net) | 1 |
| | Decision algorithm | 1 |
| | Simple diagnostic technology | 1 |
| | Custom device/app/website | 3 |
| Validation methods | Expert/*gold standard* comparison | 7 |
| | Dataset split/*cross-validation* | 6 |
| | Accuracy/user-satisfaction report | 3 |
| | Pre–post | 1 |
| | RCT + statistical analysis | 1 |
| | Clinical comparison | 1 |
| | Sensitivity/specificity analysis | 1 |

*Note: counts derived from source study-characteristics tables.*

The predominance of diagnostic-accuracy designs and the breadth of algorithmic paradigms indicate that Indonesian dental CDSS research remains in an exploratory and early-validation phase. The split between caries and periodontal foci matters because relevant metrics and ground truths differ—e.g., CAMBRA for caries risk versus *staging*/*grading* for periodontal disease. The heterogeneous validation approaches (expert comparison vs *cross-validation* vs RCT) help explain variation in confidence around performance estimates and underpin the decision to favor descriptive synthesis over quantitative pooling.

**Diagnostic Performance: Periodontal Domain**

In the periodontal domain, three studies reported high accuracy metrics, ranging from 90% to 96%. Specifically, a Dempster–Shafer-based system achieved 92.86% accuracy, a CBR/Sorgenfrei model reached 96%, and an AHP-SAWapproach achieved 90%. Furthermore, a randomized controlled trial (RCT) that tested a decision-making algorithm showed a significant increase in the likelihood of accurate staging (odds ratio [OR] 4.425; p=0.001) and grading (OR 30.303; p<0.001) compared to conventional evaluation. Additionally, a natural language processing (NLP) study utilizing a BERT model on clinical records reported 77% accuracy for staging and 75% for grading. This model outperformed its MLP comparator (59.4%/62.5%), with an F1-score for Stage III reaching 82%.

**Comparison with Conventional Practice**

In the context of dental caries, direct comparisons of CDSS with conventional tools or assessments yielded variable results. One study found that the performance of the SKOR GIGI application did not differ significantly from CAMBRA. Several other studies reported strong equivalence or agreement between CDSS and expert assessments. Conversely, some studies demonstrated the superior accuracy of CDSS relative to a baseline of student training or specific conventional approaches. In total, seven studies within this review included an explicit comparison against conventional methods or expert evaluation.

In the periodontal field, the aforementioned RCT indicated a substantial increase in the likelihood of accurate staging and grading. Meanwhile, the NLP study compared the performance of BERT and MLP models, concluding that BERT demonstrated superior performance for classification tasks based on clinical notes.

**Clinical implementation, outcomes, user acceptance, and resources**

While the implementation evidence is limited, it offers several practical insights. Firstly, school or community-oriented interventions (such as IDCRA and teacher-led screening) have been shown to improve coverage, detection, and oral health indicators.

**Table 2.** Implementation findings (examples of studies reporting outcomes)

| Study | Implementation mode | Clinical outcomes | User acceptance | Resource requirements |
|---|---|---|---|---|
| Sofiani 2024 (IDCRA) | Website; school setting | Improved oral-health indices | 96% parental awareness increase | – |
| Pratiwi 2003 | Teacher-led screening | Increased detection and coverage | – | Training + simple technology |
| Kenneth 2024 | Web expert system (Certainty Factor) | – | User satisfaction 87.81% | ReactJS, Firebase |

| | | | | |
|---|---|---|---|---|
| Aluditasari 2023 (SKOR GIGI) | Android app for parents | No difference in risk assessment vs CAMBRA | – | Android devices + parent education |
| Bumm 2023 (RCT) | Decision algorithm (student training) | Improved diagnostic accuracy | – | – |

Summary based on "Treatment Recommendation Accuracy" tables and implementation sections

This suggests that CDSS, when combined with educational or public health modalities, can effectively broaden the reach of healthcare services. Secondly, a web-based expert system reported a high level of user satisfaction (approximately 88%), indicating that CDSS can be well-accepted in digital environments. Thirdly, resource requirements vary (including Android devices, web stacks, and basic training), which underscores the importance of context-sensitive adoption planning. However, many studies failed to report clinical outcomes or user acceptance, so a full assessment of readiness for large-scale implementation will require additional pragmatic studies. A complete overview is provided in Table 2.

## DISCUSSION

### Synthesis of Findings and Implications

Overall, Indonesian-developed clinical decision support systems (CDSS) for caries demonstrate diagnostic performance that is competitive with conventional assessment. The reported ranges of sensitivity and specificity support the use of CDSS to standardize caries risk identification and lesion detection, particularly in primary care and school-based screening programs. Practically, CDSS can narrow inter-examiner variation, help prioritize referrals, and accelerate preventive decisions (e.g., patient education, fluoride use, or recall intervals) across both pediatric and adult populations.

For periodontal disease, accuracies concentrated in the higher range and evidence from a randomized trial showing greater odds of correct staging and grading with a decision algorithm indicate that CDSS can strengthen the consistency of disease classification. Clinically, this enables more uniform treatment planning—such as scaling, root planing, and risk-factor control—benefits the training of early-career clinicians, and is relevant for services where operator experience varies.

### From "algorithms" to "clinical utility"

Rather than emphasizing labels for specific approaches (e.g., deep learning, NLP, or knowledge-based systems), the practical pivot is fit-for-purpose alignment between tool, data, and clinical task:

a. Image-based systems are well suited when intraoral photography is available and objective support is needed for lesion detection; outputs can assist triage and longitudinal documentation.

b. Text/record-based systems are useful for improving the consistency of periodontal staging/grading and for surfacing guideline-concordant actions from unstructured clinical notes.

c. Rule/probabilistic systems (e.g., risk rules, certainty-factor frameworks) are relevant in resource-limited facilities because they are transparent, easy to operate, and quickly adapted to local workflows.

In short, no single approach is universally "best." Selection should be driven by data availability, the intended clinical objective (screening versus confirmation), and integration needs within existing workflows.

**Implementation evidence**

**(a) Service models and context.**

School- and community-oriented deployments (e.g., web-based risk assessment) have increased screening coverage and improved oral-health indicators, suggesting that CDSS embedded in simple public-health interventions can extend preventive reach.

**(b) User acceptance and training.**

High user satisfaction with web-based expert systems and substantial gains in parental awareness indicate good acceptability. For novice clinicians and students, decision algorithms function as didactic tools that instill standardized clinical reasoning.

**(c) Workflow integration and resource requirements.**

Successful adoption depends not only on model accuracy but also on technical maintainability, device access, and training. Lightweight platforms (web/mobile) with clear interfaces are easier to deploy; however, many studies do not specify resource needs (costs, infrastructure), leaving scale-up planning to assumptions.

**(d) Implementation gaps.**

Most publications do not report real-world clinical outcomes or systematically measure user acceptance. As a result, effects on revisit rates, quality of life, or staff workload remain uncertain. Future evaluations should pair accuracy reporting with implementation metrics (usability, service time, alert burden, and usability across facility types).

**Evidence limitations and future directions**

The evidence base is dominated by diagnostic-accuracy studies with modest samples and occasionally incomplete reporting of key metrics, while prospective/pragmatic trials remain scarce. Heterogeneity in reference standards and decision thresholds further limits cross-study comparability. To enhance applicability in routine Indonesian practice, future research should prioritize: (i) multi-site trials with standardized reporting (sensitivity, specificity, PPV/NPV); (ii) concurrent measurement of implementation outcomes and workflow fit; and (iii) explicit documentation of resource and cost requirements for adoption. With these steps, dental CDSS can more tangibly strengthen prevention, triage, and treatment for caries and periodontal disease across levels of care.

## CONCLUSION

Indonesian-developed dental CDSS demonstrate diagnostic performance comparable to, and in some cases exceeding, conventional approaches, with promising early signals of implementability. Nonetheless, heterogeneous study designs, small sample sizes, and sparse real-world outcomes limit generalizability.

Moving forward, priority should be given to pragmatic, multi-site prospective evaluations with standardized reporting (sensitivity, specificity, PPV/NPV) alongside concurrent measurement of implementation factors (usability, workflow integration, alert burden). Adoption plans should also include explicit estimates of resource and cost requirements. With these concrete steps, CDSS will be better positioned for integration and reliable use, strengthening prevention, triage, and treatment pathways for caries and periodontal disease across levels of care in Indonesia.

## CONFLICT OF INTEREST

The author declares no conflicts of interest.

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