

Bridging Health Informatics Across Pharmacy and Dentistry: A Scoping Review of Digital Transformation, Interoperability, Clinical Decision Support, Artificial Intelligence, and Patient Safety

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Abstract

Background: Pharmacy and dentistry are rapidly digitizing, yet information ecosystems remain poorly connected. This gap is clinically relevant because medication/systemic- health/oral-health information may be mutually relevant for safe care. **Objective:** Map digital health technology/electronic health record (EHR)/informatics literature on interoperability, clinical decision support systems (CDSS), artificial intelligence (AI), and patient safety across pharmacy and dentistry and identify cross-professional gaps in the evidence. **Methods:** Structured as a scoping review (Population–Concept–Context framework; Joanna Briggs Institute [JBI]/Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews [PRISMA-ScR] reporting). Study evidence maps by technology, clinical function, interoperability maturity, safety mechanism, implementation determinant, and outcome. **Results:** Literature demonstrates robust digital advancement within each profession, but limited evidence supporting integrated pharmacy dentistry clinical workflows. Dental informatics evidence evolved with each stage of electronic records, coding, imaging, data capture, and reuse competency. Pharmacy literature proliferated AI-supported medication management and decision support. Interoperability/data quality/workflow integration/alert governance/human oversight/privacy/bias/equity repeatedly emerge as factors that determine whether or not digitalization delivers net safety gains. **Conclusion:** Cross-cutting gaps are opportunities: not necessarily for further digitization as individual professions or specialties, but interoperable, context-aware, governed digital ecosystems that help professionals keep patients safer overall.

Keywords: dental informatics; pharmacy informatics; digital health; interoperability; clinical decision support; artificial intelligence; patient safety; electronic health records; scoping review.

Introduction

Digital transformation is often less about swapping paper processes for digital versions and more about redesigning clinical and administrative workflows and how information flows through them. This includes electronic health records (EHRs), electronic prescribing, clinical decision support, artificial intelligence/machine learning, health-information exchange, telehealth, and patient-facing technologies that alter how health information is created, shared, interpreted, and acted upon clinically (World Health Organization WHO, 2021a; Li et al., 2022).

Pharmacy is an information-heavy clinical domain, given medication safety relies on accurate longitudinal data about prescriptions, allergies, adverse reactions, diagnoses, labs, prior therapies, and dispensing history. Digital pharmacy workflow(s) has increasingly expanded to include medication reconciliation, interaction checks, dose optimization, pharmacovigilance, antimicrobial stewardship, and clinical decision support. (Ranchon et al., 2023; Chalasani et al., 2023; Hatzimanolis et al., 2025).

Dentistry has also transitioned to electronic dental records, digital radiography, 3-dimensional imaging, computer aided-design and manufacturing technologies, digital treatment planning software, tele dentistry, and AI-assisted diagnostic image interpretation. But dental data is not always incorporated into longitudinal health records. This creates missed opportunities: oral-health data can be relevant to medication decisions; medication and systemic-health data can be critical to safely performing dental procedures (Ballester Benoit et al., 2022; Schwendicke et al., 2020).

So, the real question is not if pharmacy and dentistry should digitize. They already have. Rather, the harder question is if and how these systems can share clinically meaningful data at the right time and in the right context – with adequate governance to enhance, not detract from patient safety. (WHO, 2021a; WHO, 2021b)

Given the scope of this topic crosses numerous technologies, professions, study designs and outcomes, it lends itself to a scoping-review approach to identify key themes across the breadth of evidence and research gaps (Peters et al., 2020; Tricco et al., 2018).

2. Review Aim and Questions

The goal is to scope out the literature on how health informatics can help connect pharmacy and dentistry, especially interoperability, CDSS, artificial intelligence (AI), and patient safety.

1. What digital tools and informatics have been investigated in pharmacy and dentistry?
 2. What use or proposals exist for EHRs, health-information exchange, and interoperability to link oral health and medication information?
 3. What CDSS and AI tools have been applied to clinical decision-making in either or both domains?
 4. What patient-safety outcomes and technology-related hazards have been reported?
 5. What implementation, usability, workforce, privacy, governance, and equity issues affect adoption?
 6. Where do the largest gaps in evidence lie that hinder mature pharmacy–dentistry informatics?
3. Eligibility Framework: Population–Concept–Context (PCC)

Table 1. Population–Concept–Context (PCC) Framework for the Scoping Review

Element	Operational definition	Examples
Population	Patients and health professionals using or affected by digital systems	Patients; pharmacists; dentists; physicians; dental hygienists
Concept	Digital technologies used for information management, decision support, coordination, or safety	EHR; e-prescribing; CDSS; AI; interoperability; HIE; imaging
Context	Pharmacy, dentistry/oral health, and connected care environments	Community/hospital pharmacy; dental clinics; integrated services

Source: Adapted to the review question from JBI scoping-review methodology (Peters et al., 2020).

4. Proposed Review Methodology

This protocol has been registered with the Open Science Framework as osf.io/74azw. This manuscript will be structured as a scoping review. When complete, the review will adhere to the reporting guidelines for JBI scoping-review methodology and PRISMA-ScR reporting. Protocol items to be completed prior to formal submission include planned databases, finalized search strings, eligibility criteria, screening workflow, data- charting fields, and synthesis method. Counts for number of searches conducted, screened, excluded, and final included studies should only be populated after the review is conducted (i.e., following database search & screening). No study-flow numbers will be estimated/altered here (Peters et al., 2020; Tricco et al., 2018).

4.1 Information sources

Planned sources include PubMed/MEDLINE, Embase, Scopus, Web of Science Core Collection, CINAHL, and relevant health-information/technology literature. Citation chaining and reference-list screening should supplement database searching.

4.2 Search architecture

The search strategy needs to include four blocks of concepts: pharmacy; dentistry/oral health; informatics/digital technologies; and decision support/interoperability/patient safety. Terms should include database-specific controlled vocabulary and free text words. Reproducible search reporting including PRISMA-S guidelines where applicable should be used (Rethlefsen et al., 2021).

4.3 Screening and data charting

Title/abstracts and full texts should be screened independently by two reviewers. A piloted form should be used to chart study design, country, setting, professional domain, technology, data source, interoperability characteristics, technology purpose (clinical function), safety mechanism (if applicable), reported outcomes, implementation determinants, study limitations, and gaps in evidence.

4.4 Synthesis

Evidence should be mapped, not pooled. Characteristics, technology distributions, professional domains, interoperability maturity, safety mechanisms, implementation themes and evidence gaps should be studied in the final review.

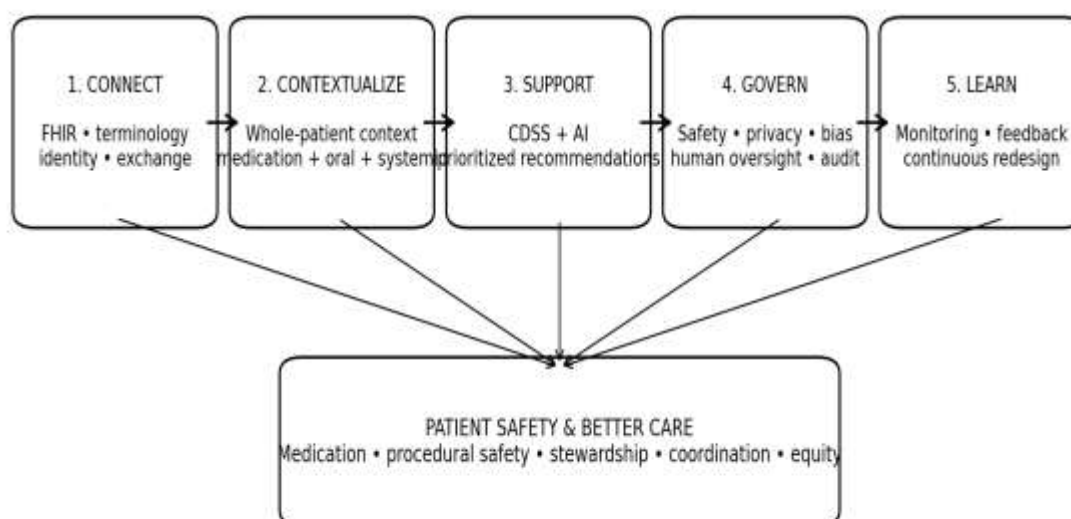


Figure 1. Interoperability and contextualization precede decision support, governance, and continuous learning.

5. Pharmacy Informatics: Digital Maturity and Safety

Pharmacy informatics evolved from dispensing automation to medication-management ecosystems. Informatics-enabled systems can link prescribing, dispensing, administration of medications, lab values, allergies, reconciliation, and clinical decision support (CDSS). This connectivity enables pharmacists to practice as information-intensive clinicians (Ranchon et al., 2023; Al- Taie et al., 2026).

Technology is not always safe. Medication CDSS tools can help identify drug interactions, duplicate therapy, contraindications, dosing errors and monitoring requirements. Poorly configured alerts create alert fatigue, overrides and workarounds. (Olakotan & Yusof, 20 21; Muylle et al., 2019).

Table 2. Digital Health Applications in Pharmacy: Clinical Functions, Benefits, and Safety Risks

Domain	Capability	Potential Benefit	Principal Hazard
Medication reconciliation	Longitudinal medication lists	Continuity/error prevention	Incomplete records
CDSS	Interaction/dose/allergy alerts	Risk detection	Alert fatigue
E-prescribing	Electronic transmission	Less transcription error	Wrong patient/drug
Pharmacovigilance	Automated signal detection	Earlier safety signals	False positives/bias
Stewardship	Guideline-linked support	Appropriate antimicrobial use	Workflow disruption
AI/analytics	Risk prediction/prioritization	Targeted review	Drift/opacity

Sources: Ranchon et al. (2023); Chalasani et al. (2023); Hatzimanolis et al. (2025); Muylle et al. (2019).

6. Dental Informatics: Digitalization Without Full Integration

Clinical informatics relevant to dentistry includes electronic dental records, dental imaging, treatment planning, dental coding, reuse of dental data, tele dentistry, artificial intelligence in dentistry. The move to digital capability in these areas is rapidly accelerating. However, interoperability of dental information with longitudinal health records is immature (Ballester Benoit et al., 2022; Schwendicke et al., 2020).

The important gap is not only missing electronic dental records. It's insufficient reuse of dental information for clinical decision-making outside of dentistry. When oral- health information is siloed, drug-related risks and oral presentations of systemic disease can go unnoticed by non-dental clinicians. In turn, dental clinicians may miss out on receiving systemic information in a timely manner to perform procedures safely (Ballester Benoit et al., 2022; Li et al., 2022).

Table 3. Digital Health Applications in Dentistry: Capabilities, Benefits, and Interoperability Gaps

Domain	Capability	Potential Benefit	Key Gap
Dental EHR	Structured documentation	Longitudinal oral record	Variable interoperability
Imaging	Digital radiography/3D	Diagnostic support	Integration/validation
AI	Image interpretation/prediction	Decision augmentation	External validation/bias
Teledentistry	Remote triage	Access/continuity	Equity/data limits
Data reuse	Research/quality analytics	Learning health system	Coding/standardization
CDSS	Risk/treatment support	Consistency	Limited real-world evidence

Sources: Ballester Benoit et al. (2022); Schwendicke et al. (2020)

Figure 2. Pharmacy–Dentistry Information Flow

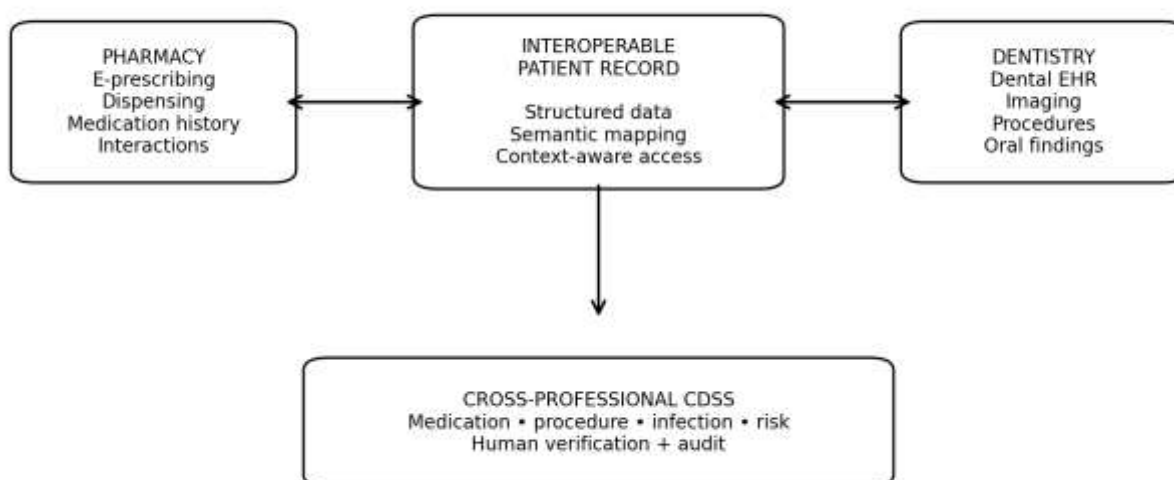


Figure 2. Pharmacy and dental information should converge through an interoperable patient record before context-aware decision support is applied.

7. Interoperability: The Missing Bridge

Interoperability has technical, syntactic, and semantic components. You can exchange a document successfully and still not communicate the clinical meaning of a medication, allergy, procedure, or oral-health finding. HL7 FHIR represents one major standards-based underpinning for structured exchange. However, safe interoperability also includes terminology mapping, implementation guidance, patient identity, governance, and agreement on clinically meaningful minimum datasets (WHO, 2021a; HL7 International, 2023; Li et al., 2022).

Table 4. Interoperability Layers Required for Safe Pharmacy–Dentistry Information Exchange

Layer	Capability	Safety question
Identity	Reliable patient matching	Is this the correct patient?
Syntax	Machine-readable structure	Can the receiving system parse it?
Semantics	Shared terminology/meaning	Is it interpreted correctly?
Workflow	Right information at right time	Will the clinician see it before acting?
Governance	Consent, access, audit, correction	Who is accountable?

Sources: HL7 International (2023); Li et al. (2022); WHO (2021a).

8. Clinical Decision Support Across the Two Professions

CDSS are considered the link between information and clinical action in practice. Information that would not otherwise have been visible to another professional at the point of care can be brought to attention through the use of cross-professional CDSS (AHRQ, 2024). An important distinction that needs to be made here is that

improvement in process measures or clinician behavior does not equal evidence of improved patient outcomes. Future research should include both process and patient-safety outcomes (AHRQ, 2024).

Table 5. Cross-Professional Clinical Decision-Support Opportunities Linking Pharmacy and Dentistry

Scenario	Decision-support opportunity	Priority outcome
Dental procedure + anticoagulant	Medication and relevant clinical context	Medication/procedural incidents
Dental antibiotic	Allergy, interactions, recent antimicrobial exposure	Appropriateness/adverse events
Post-dental analgesia	Current medicines and organ-function context	Duplicate therapy/toxicity
Diabetes + oral infection	Link systemic and oral information	Referral/control/complications
Medication-related oral effects	Connect exposure to oral findings	Recognition/medication review
Immunosuppression + procedure	Surface therapy and infection risk	Procedure-related complications

Source: Illustrative synthesis informed by CDSS and medication-safety literature (AHRQ, 2024; Ranchon et al., 2023).

9. Artificial Intelligence: Opportunity with a Safety Boundary

AI may augment informatics by providing classification, prediction, image interpretation, anomaly detection, prioritization, and natural-language assistance. Visible AI activity in dentistry applies to imaging/diagnosis. Pharmacy applications can include medication-risk prediction, pharmacovigilance, adherence analytics, and clinical prioritization. (Schwendicke et al., 2020; Hatzimanolis et al., 2025; Al-Taie et al., 2026) AI should support rather than silently substitute for professional judgment. Harms include dataset shifts, bias, miscalibration, bias, automation bias, opacity, generative- model hallucination, cybersecurity risk, and liability opacity (WHO, 2021c; Kelly et al., 2019).

Table 6. Key Artificial Intelligence Risks and Proposed Safety Controls in Pharmacy and Dentistry

Risk	Why it matters	Control
Bias	Unequal performance	Representative data + subgroup validation
Model drift	Performance changes	Continuous monitoring
Automation bias	Over-trust	Human verification/training
Opacity	Difficult challenge	Traceability/explainability
Hallucination	Unsupported output	Grounding/source verification
Privacy/security	Sensitive data exposure	Access control/audit/security

Sources: WHO (2021c); Kelly et al. (2019); Hatzimanolis et al. (2025).

Figure 3. Digital Transformation and Patient-Safety Balance

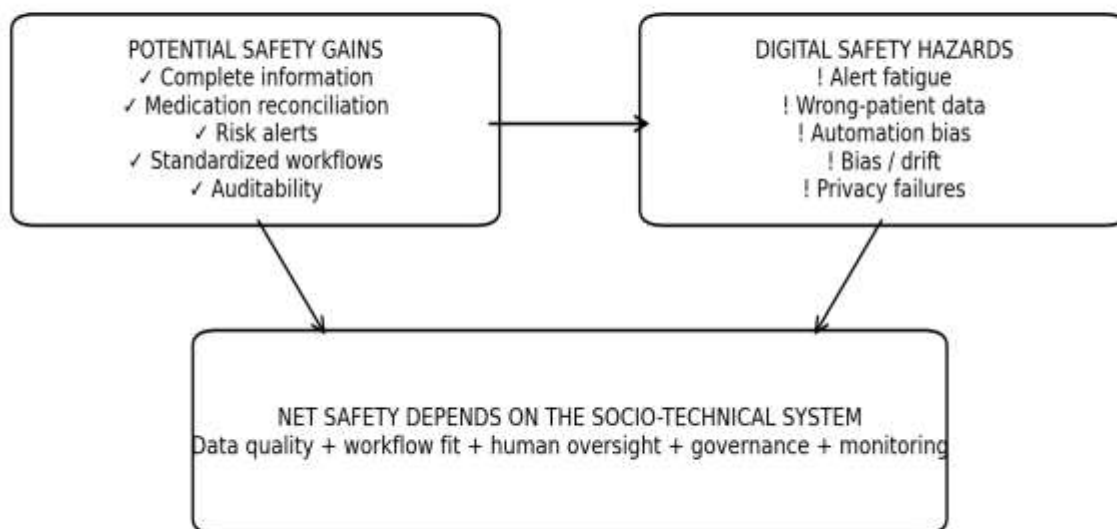


Figure 3. Digital tools create both safety gains and new hazards; net benefits depend on the wider socio-technical system.

10. Patient Safety as a Socio-Technical Outcome

Digital systems can mitigate risk by facilitating information accessibility, standardizing medication and allergy information, enabling evidence-based decision support, minimizing transcription errors, and designing auditable workflows. Digital systems can also create new hazards such as alert fatigue, wrong-patient association, incomplete information, poor user interfaces, automation bias, interoperability errors, privacy vulnerabilities, and machine learning bias (WHO, 2021b; Li et al., 2022; Keen et al., 2020). Patient safety should be assessed at the socio-technical system level—not just the algorithm itself. The interaction between technology, data, professionals, patients, workflow, organizational context, and governance produces downstream safety in practice (WHO, 2021b; Keen et al., 2020).

Table 7. Patient-Safety Mechanisms and Potential Unintended Consequences of Digital Health Technologies

Safety mechanism	Potential benefit	Potential unintended harm
Information availability	More complete clinical context	False confidence if incomplete
Decision support	Prompt risk recognition	Alert fatigue
Automation	Reduced repetitive work	Automation bias/workarounds
Interoperability	Continuity	Propagation of incorrect data
AI	Pattern recognition	Bias/drift/opacity

Auditability	Incident investigation	Privacy burden
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Sources: WHO (2021b); Li et al. (2022); Keen et al. (2020).

11. Implementation, Workforce, and Organizational Readiness

Implementation is where digital interventions succeed or fail at delivering value. A strong pathway starts with identifying a true safety/workflow issue, maps the information flow, cocreates the intervention with users, validates performance, pilot-test in practice, and track outcomes/unintended consequences (WHO, 2021a; Li et al., 2022).

Table 8. Implementation Roadmap for Cross-Professional Pharmacy–Dentistry Informatics

Phase	Key question	Deliverable
Needs assessment	What problem exists?	Baseline + measurable target
Data mapping	Where is information?	Data map
Co-design	How should support appear?	Workflow prototype
Validation	Is it safe and accurate?	Clinical safety case
Pilot	What happens in practice?	Outcome/incident review
Scale	Can it work across sites?	Governance/training plan
Monitoring	Does safety persist?	Performance dashboard

Sources: WHO (2021a); Li et al. (2022).

12. Equity, Privacy, and Governance

Having said all of this, an integrated record should not be used as a rationale for unrestricted access. Role-based access, consent, auditability, data minimization, correction mechanisms and notices of transparent secondary-use policies are all important. Fairness also requires assessing access, usability, model performance and outcomes by group for those who may be digitally disenfranchised (WHO, 2021a; WHO, 2021c).

The goal shouldn't be to share as much data as possible. Instead, we should aim for safe, useful data exchange that is context aware to enhance a decision, while limiting unnecessary exposure and cognitive load.

13. Major Evidence Gaps

❑ Evaluation of truly integrated pharmacy–dentistry informatics technology solutions is limited compared to stand-alone professional informatics solutions.

❑ Reuse of dental information in longitudinal cross-setting decision support is relatively immature.

❑ Evidence supporting hard patient outcomes resulting from CDSS is not as strong as that for processes of care and clinician behavior.

❑ Technical interoperability has outpaced semantic interoperability and clinically validated data reuse.

❑ Governance of cross-professional alerts has been largely undefined.

❑ Stronger external validation, prospective testing, calibration, subgroup analysis, and post-deployment monitoring of AI findings are needed.

❑ Issues related to long-term maintenance, model drift, unintended consequences, and de-implementation are underreported.

❑ Patient-facing aspects of cross-professional oral health and medication-data sharing remain understudied.

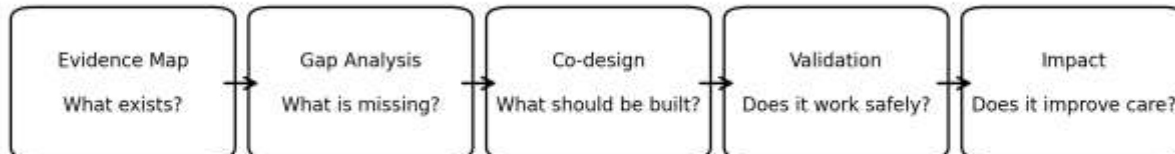
❑ More evidence from resource-constrained environments and middle-income countries is needed.

Table 9. Major Evidence Gaps and Priority Areas for Future Research

Evidence gap	Priority research response
Limited integrated pharmacy–dentistry studies	Multi-site cross-professional evaluations
Underuse of dental data	Develop and validate interoperable oral-health datasets
Weak hard-outcome evidence	Prospective patient-safety outcome studies
Semantic interoperability gap	Terminology mapping + minimum datasets
Alert governance gap	Cross-professional alert design and evaluation
AI validation gap	External/prospective/subgroup validation
Limited long-term evidence	Post-deployment monitoring and de-implementation research
Limited patient perspective	Co-design and patient-experience studies
Geographic evidence imbalance	Research in LMIC and resource-constrained settings

Authors' synthesis is based on mapped literature and methodological framework.

Figure 4. From Evidence Mapping to Research Impact



RESEARCH AGENDA: cross-professional outcomes • implementation • equity • long-term safety

Figure 4. A research roadmap linking evidence mapping to implementation and measurable patient impact.

14. Proposed CONNECT–CONTEXTUALIZE–SUPPORT–GOVERN–LEARN Framework

The framework is intentionally sequential. Advanced AI or CDSS cannot compensate for unreliable identity, incomplete data, poor semantic interoperability, or unsafe workflow integration.

Table 10. CONNECT–CONTEXTUALIZE–SUPPORT–GOVERN–LEARN Framework for Integrated Pharmacy–Dentistry Informatics

Domain	Core question	Operational principle	Example measure
CONNECT	Can systems exchange information?	Standards-based exchange	Exchange success
CONTEXTUALIZE	Does the system understand the patient?	Longitudinal clinical context	Record completeness
SUPPORT	Does information improve decisions?	Prioritized, explainable support	Recommendation acceptance
GOVERN	Is the system safe/accountable?	Human oversight, privacy, bias, audit	Incidents/model performance
LEARN	Does it improve over time?	Continuous evaluation/redesign	Safety/process change

Authors' proposed framework, informed by WHO (2021a), HL7 International (2023), and patient-safety literature.

15. Evidence Interpretation and Strength of the Literature

Research evidence is mixed. Guidance on the methods of scoping reviews is mature. Profession-specific evidence is more varied. Informatics research into dentistry shows advances in coding, data capture, electronic health records, and data reuse. Few studies have analyzed CDSS reusing electronic dental-record data specifically. Recent pharmacy literature shows burgeoning AI applications for medication review, interactions/adverse effects, medication errors, and prioritization. Interpreted cautiously, these patterns show digital maturity varies within professions and has not yet reached maturity between professions (Ballester Benoit et al., 2022; Al-Taie et al., 2026).

16. Discussion

One takeaway from this data may be that pharmacy and dentistry should be viewed less as separate informatics silos and more as complementary disciplines. Pharmacy brings fairly mature medication-management systems. Dentistry brings us tantalizing glimpses of next-generation oral-health records, imaging, and AI tools. What we lack is the connective tissue of interoperability that allows us to usefully exchange information between them. (Ballester Benoit et al., 2022; Ranchon et al., 2023)

The safest thing we can probably say is that digitalization doesn't intrinsically lead to better outcomes. Improved information must still be relevant to our interventions and workflows, adopted by providers and accepted by patients, and governed responsibly. Attributing process gains to CDSS specifically should not be confused with evidence that hard outcomes are improved. (Li et al., 2022; AHRQ, 2024)

I think we should start thinking about interoperability as an element of clinical safety. Both the dentist who can't see a patient's medications, and the pharmacist who can't see that patient's oral-health data, are working with incomplete information that could put the patient at risk. But just as unrestricted access poses privacy risks, oversharing can cause cognitive load injuries. We want the safe exchange of information that is clinically meaningful. (WHO, 2021a; Li et al., 2022)

Another way to think about this: AI should be viewed as a layer on top of this stack, not the crown jewel. Build to the system first: trustworthy data, semantic interoperability, workflow integration, clinical decision support, governance, evaluation. Then point your AI at it (WHO, 2021c; Kelly et al., 2019).

17. Limitations

A scoping review is intended to create a map of breadth and gaps vs. yielding a pooled estimate of effectiveness. Due to expected heterogeneity in technologies, study designs, outcomes, and professional practice contexts,

limited head-to-head comparisons will be possible. Language limitations and exclusion of unpublished studies may affect the resulting evidence map. Lastly, and most importantly, the numerical PRISMA-ScR study-flow results, final counts of included studies, and quantitative summaries should be derived from your complete database search and screening process. They should never be fabricated.

18. Conclusion

Pharmacy and dentistry are each experiencing significant digitization. However, the informational ecosystem around them is not well connected. There is a growing base of evidence supporting a shift away from siloed digitization and towards interoperable patient-centered informatics where medication, systemic-health, and oral-health information can safely guide decision-making across care continuums. Clinical decision support systems (CDSS) and artificial intelligence (AI) have an important role to play but are only as good as the data they are built on (quality, semantic interoperability), they fit into the clinical workflow, and human involvement, governance, and oversight structures. These frameworks must also be continuously evaluated to measure effectiveness.

We propose the acronym CONNECT–CONTEXTUALIZE–SUPPORT–GOVERN–LEARN as a pragmatic approach for future researchers, implementers, and policymakers. Technology should be measured not by how ‘high-tech’ it is, but if it helps clinicians make safer, better-informed decisions for the whole patient.

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