Artificial Intelligence in Clinical Decision Support

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Objectives

Recall

- The current landscape and underlying mechanisms of artificial intelligence tools utilized in clinical decision support.

Identify

- The ethical, regulatory and operational challenges associated with integrating machine learning algorithms into routine clinical workflows.

Recognize

- Evidence-based frameworks to assess the clinical validity, safety and impact of AI-driven interventions on patient outcomes and medication management.

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Clinical Decision Support

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What is Clinical Decision Support (CDS)?

Health information technology tool that provides timely evidence-based information (usually at the point of care) to help inform decisions about a patient's care

- Good CDS:
  - Supports clinical judgement
  - Provides updated patient-specific recommendations
  - Integrates into workflow
  - Minimizes alert fatigue

Source: Agency for Healthcare Research and Quality. (n.d.). Clinical decision support. https://www.ahrq.gov/cpi/about/otherwebsites/clinical-decision-support/index.html

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Common CDS Tools Used in Practice

Medication safety alerts

Dose optimization support

Order sets and care pathways

Clinical reminders

Diagnostic and risk prediction tools

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Traditional CDS Components

Knowledge Base	• Guidelines, rules, evidence, predictive models
Inference Engine	• Logic that matches patient data to rules
Patient Data Inputs	• Labs, meds, vitals, diagnoses, demographics
Delivery Mechanism	• Alerts, order sets, dashboards, documentation tools

Source: Jiang, Y., Qiu, B., Xu, C., & Li, C. (2017). The Research of Clinical Decision Support System Based on Three-Layer Knowledge Base Model. Journal of healthcare engineering, 2017, 6535286. https://doi.org/10.1155/2017/6535286

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Challenge: Alert Fatigue

Excessive, low-value or non-specific alerts overwhelm clinicians, leading to a loss of confidence in the CDS

Loss of CDS trust has been shown to result in CDS override rate of 49-96%

This loss in trust and inability to keep up with alert volume results in potentially important alerts being overridden

Reduces patient safety and contributes to workflow disruption and burnout

Source: Van der Sijs H, Aarts J, Vulto A, Berg M. Overriding of drug safety alerts in computerized physician order entry. J Am Med Inform Assoc. 2006;13(2):138–147. doi:10.1197/jamia.M1809

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Artificial Intelligence (AI)

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Artificial Intelligence Background & Evolution

How AI works

- Iterative learning from massive data streams allows for the execution of complex tasks without explicit, pre-defined logic trees

Machine Learning (ML)

- A subset of AI that identifies hidden patterns among many interacting variables, allowing for pattern-based prediction

Natural Language Processing (NLP)

- Enables AI to read and extract structured variables from unstructured data

Large Language Models (LLMs)

- AI designed to process and generate human language

Source: Shool, S., Adimi, S., Saboori Amleshi, R., Bitaraf, E., Golpira, R., & Tara, M. (2025). A systematic review of large language model (LLM) evaluations in clinical medicine. BMC medical informatics and decision making, 25(1), 117. https://doi.org/10.1186/s12911-025-02954-4

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How AI is Used Today in Healthcare

Predictive analytics

- Continuous monitoring of the Electronic Health Records (EHR) to identify risks to patients (e.g., sepsis, adverse drug reactions)

Administrative burden

- LLMs speed up clinical documentation by use of ambient listening and transcribing, freeing time to be spent with the patient

2025/2026 Adoption Trends

- In 2026, 68% of U.S. healthcare systems reported using or planning to use AI platforms for clinical note-taking and 43% for AI-based clinical documentation improvement

Source: Health System Adoption of AI Solutions: February 2026. Eliciting Insights. https://elicitinginsights.com/wp-content/uploads/2026/03/219_ElicitingInsights_AI_Infographic_Feb2026_Final.pdf

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Potential of AI in Clinical Decision Support

- Models can be trained to reduce unnecessary or low-value alerts, mitigating alert fatigue
- Enables predictive decision-making, such as identifying patients at risk of clinical deterioration
- Enhances personalization of care by tailoring recommendations based on patient-specific data
- Able to analyze clinical notes, images and other unstructured data, offering more insight than traditional CDS
- Continual adaptation allows for more thorough analysis than static rule-based CDS

Source: Wong A, Flanagan T, Covington EW, et al. Forecasting the impact of artificial intelligence on clinical pharmacy practice. J Am Coll Clin Pharm. 2025;8(4):302–310. doi:10.1002/jac5.70004

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Assessment Question 1

Which of the following best describes a primary application of machine learning within pharmacy informatics for Clinical Decision Support (CDS)?

a. Replacing the need for pharmacist verification of high-risk medications.

b. Analyzing patient-specific EHR data in real-time to optimize dosing regimens and predict adverse drug events.

c. Aggregating historical claims data to determine overall community disease prevalence.

d. Automating the physical dispensing of medications in the central pharmacy

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Assessment Question 1 Answer

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Framework to Evaluate Usefulness of AI

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Evaluation Framework Key Considerations

Clinical validity, context and sensitivity

- Does the model address a real clinical problem?
- Is it trained on data relevant to our patient population?
- Is it being used within its intended clinical context?
- How does it balance alert sensitivity and specificity?

Workflow integration

- Is the CDS interruptive or passive?
- Does it integrate into the computerized provider order entry (CPOE) interface?
- Does it add extra steps to the workflow?

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Evaluation Framework Key Considerations

Safety and bias mitigation

- Does the system communicate uncertainty clearly?
- Is there risk of over-reliance on AI recommendations?
- Has the model been evaluated for bias in different patient populations?

Continuous monitoring and governance

- Who is responsible for the model after deployment?
- Is there a process to monitor for performance drift over time?
- Are outputs regularly reviewed for accuracy and safety?

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Assessment Question 2

When integrating a new AI-driven CDS alert into the electronic health record, what is a primary operational challenge the pharmacy informatics team must manage?

a. Ensuring the alert fires for every possible theoretical interaction to maximize safety.
b. Training the AI model to permanently bypass human override capabilities.
c. Restricting the AI's access to patient lab values to maintain HIPAA compliance.
d. Balancing the sensitivity and specificity of the algorithm to prevent alert fatigue among clinicians.

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Assessment Question 2 Answer

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Evaluating AI: Technical Performance vs. Clinical Utility

Technical vs. Clinical Metrics

Technical metrics (computation speed, alert volume) do not necessarily correlate to clinical impact

How do we identify clinical impact?

- Overly specific metrics limit clinical applicability
- Overly sensitive metrics leads to increased alert volume

Functional vs. Useful

Does the model perform well in testing environments but fail to support best clinical practices?

Pitfalls to avoid:

- Increases in cognitive burden
- Disruptions to workflow
- Lack of clinician adoption

Source: Elhaddad M, Hamam S. AI-driven clinical decision support systems: an ongoing pursuit of potential. Cureus. 2024;16(4):e57728. doi:10.7759/cureus.57728

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CDS Clinical Impact: Patient Outcomes

True Measure of Success

- Demonstrates measurable improvement in patient outcomes
- Not based on algorithm complexity or technical performance

Some key indicators of clinical utility:

- Reduced time-to-intervention for critical therapies
- Measurable reductions in length of stay or readmission rates
- Improved outcomes in high-risk patient populations

Pharmacy-specific benchmark (AHRQ)

Reduction in adverse drug events (ADEs) is a key indicator of effective medication-related CDS

Source: David Atkins, Kenneth Fink, Jean Slutsky. Better Information for Better Health Care: The Evidence-based Practice Center Program and the Agency for Healthcare Research and Quality. Ann Intern Med.2005;142:1035-1041. [Epub 21 June 2005]. doi:10.7326/0003-4819-142-12_Part_2-200506211-00002

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Assessment Question 3

When evaluating the real-world impact of a newly implemented AI-driven CDS tool, which metric provides the most robust evidence of its clinical utility?

a. The computational speed of the algorithm's predictions.
b. The mathematical complexity of the neural network used in the model
c. A measurable reduction in the incidence of targeted adverse drug events following implementation.
d. The total volume of alerts generated by the system per month

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Assessment Question 3 Answer

When evaluating the real-world impact of a newly implemented AI-driven CDS tool, which metric provides the most robust evidence of its clinical utility?

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Research-based Review on the Use of AI in CDS

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Comparative Analysis of Generative Artificial Intelligence System

Clinical Problem:

- Growing use of generative AI in clinical pharmacy, but safety is uncertain
- AI may give confident yet incorrect recommendations
- Lacks built-in safeguards of traditional CDS

AI Method

- Evaluated multiple popular LLMs on clinical pharmacy cases
- Generated text-based recommendations (no rule-based alerts)

Study Design:

- Double-blind study with 6 clinical pharmacists
- Reviewed 48 real-world cases
- Scored on: **accuracy, rigor, applicability, logic, conciseness, generalizability**

Source: Li L, Du P, Huang X, et al. Comparative analysis of generative artificial intelligence systems in solving clinical pharmacy problems: mixed methods study. JMIR Med Inform. 2025;13:e76128. doi:10.2196/76128

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Comparative Analysis of Generative Artificial Intelligence System

Results:

- Strong performance in information synthesis & structure
- Major safety gaps: **75% missed life-threatening contraindications**
  - Example: failed to flag ethambutol in optic neuritis
- 90% lacked clinical context (formularies, resistance patterns)

Clinical Relevance:

- AI is useful for support, but not safe independently
- Requires human oversight (pharmacist + provider)
- Needs integration with CDS tools & local data
- Key: Augmented intelligence, not autonomous decisions

Source: Li L, Du P, Huang X, et al. Comparative analysis of generative artificial intelligence systems in solving clinical pharmacy problems: mixed methods study. JMIR Med Inform. 2025;13:e76128. doi:10.2196/76128

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AI-driven CDS (human-in-the-loop decision support)

Clinical Problem:

- Black Box AI is a system that gives a recommendation without rationale.
- Not showing rationale behind recommendations make it harder for clinicians to judge whether to trust it.

AI Method:

- Compared two AI-CDS designs: black-box AI (recommendation only) vs uncertainty-aware AI (recommendation + confidence of recommendation by percentage)

Study Design:

- Randomized trial: web-based medication verification tasks comparing no AI, black-box AI and uncertainty-aware AI.
- Included both accurate scenarios and incorrect (“hallucination”) AI recommendations

Source: Lester C, Rowell B, Zheng Y, et al. Effect of uncertainty-aware AI models on pharmacists’ reaction time and decision-making in a web-based mock medication verification task: randomized controlled trial. JMIR Med Inform. 2025;13:e64902. doi:10.2196/64902

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AI-driven CDS (human-in-the-loop decision support)

Result:

- Baseline accuracy (no AI): **81.2%**
- Both AI types improved safety with **accurate recommendations**
- Best: **Uncertainty-aware AI -> 96.1% accuracy** rejecting unsafe orders
- When AI was wrong: higher rejection with **uncertainty-aware (83.3% vs 76.7%)**

Clinical Relevance:

- **Confidence transparency matters as much as prediction accuracy**
- Confidence display -> better clinical skepticism & safety
- Helps reduce automation bias
- Reinforces pharmacist + provider oversight

Source: Lester C, Rowell B, Zheng Y, et al. Effect of uncertainty-aware AI models on pharmacists' reaction time and decision-making in a web-based mock medication verification task: randomized controlled trial. JMIR Med Inform. 2025;13:e64902. doi:10.2196/64902

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NLP Identification of Goals-of-Care Documentation in EHRs

Clinical Problem

- Goals of care often buried in free-text notes
- Hard to access during prescribing decisions
- Risk of misaligned pharmacotherapy in serious illness

AI Method

- NLP model using tokenization + logistic regression
- Extracts goals-of-care documentation from notes

Study Design

- Retrospective development and validation study using EHR note data, with performance evaluated using Area Under the Receiver Operating Characteristic Curve (AUC).

Source: Lee RY, Brumback LC, Lober WB, et al. Identifying goals of care conversations in the electronic health record using natural language processing and machine learning. J Pain Symptom Manage. 2021;61(1):136–142.e2. doi:10.1016/j.jpainsymman.2020.08.024

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NLP Identification of Goals-of-Care Documentation in EHRs, *continued*

Results

- NLP model showed strong performance detecting goals-of-care in notes
- Effectively identifies patient preferences from unstructured data

Clinical Relevance

- Enables real-time visibility of goals of care in prescribing
- Helps prevent goal-discordant treatments
- Supports alerts for care teams
- Improves patient-centered care & deprescribing

Source: Lee RY, Brumback LC, Lober WB, et al. Identifying goals of care conversations in the electronic health record using natural language processing and machine learning. J Pain Symptom Manage. 2021;61(1):136–142.e2. doi:10.1016/j.jpainsymman.2020.08.024

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NLP-Based Detection of Delirium Using CAM Criteria from Unstructured Clinical Notes

Clinical Problem

- Delirium often missed due to documentation in free-text notes
- Leads to missed interventions; manual review not scalable

AI Method

- Development of Natural Language Processing (NLP) models mapped to standardized Confusion Assessment Method (CAM) criteria, including: Acute onset, Inattention, Disorganized thinking, Altered level of consciousness
- Algorithm scans unstructured clinical notes to identify patterns consistent with delirium

Study Design

- Retrospective model development and validation study comparing:
  - NLP-based identification of delirium
  - Traditional Chart-based identification

Source: Fu S, Lopes GS, Pagali SR, et al. Ascertainment of Delirium Status Using Natural Language Processing From Electronic Health Records. J Gerontol A Biol Sci Med Sci. 2022;77(3):524-530. doi:10.1093/gerona/glaa275

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NLP-Based Detection of Delirium Using CAM Criteria from Unstructured Clinical Notes

Result

- NLP models identified significantly more delirium cases than ICD coding
- Demonstrated improved sensitivity for detecting delirium from clinical documentation

Clinical Relevance

- Provides earlier and more accurate identification of delirium using routine documentation
- Could support:
  - Medication review (e.g., identifying medications that contribute to delirium such as anticholinergics, benzodiazepines, opioids)
  - More timely multidisciplinary interventions

Source: Fu S, Lopes GS, Pagali SR, et al. Ascertainment of Delirium Status Using Natural Language Processing From Electronic Health Records. J Gerontol A Biol Sci Med Sci. 2022;77(3):524-530. doi:10.1093/gerona/glaa275

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The ALERT Trial: AI-Driven CDS

Clinical Problem:

- Aortic stenosis (AS) and mitral regurgitation (MR) have poor prognoses if untreated (e.g. ~2-year survival after symptom onset for AS).
- Up to 50% of symptomatic patients remain undertreated, with significant disparities affecting racial minorities, women and rural populations.

AI Method:

- An AI platform using Natural Language Processing (NLP) is used in extracting clinically meaningful data from unstructured echocardiogram reports

Study Design:

- Cluster-randomized controlled trial across 5 US health systems
- **Intervention group:** receives automated EHR inbox alerts with guideline-based recommendations
- **Control group:** usual care without notifications
- System identifies undertreated patients and prompts referral to an interdisciplinary team

Source: Batchelor WB, Lindman BR, Coylewright M, et al. A randomized trial evaluating automated notifications for the identification and treatment of aortic stenosis and mitral regurgitation: the ALERT study. J Soc Cardiovasc Angiogr Interv. 2025. doi:10.1016/j.jscai.2025.104040

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The ALERT Trial: AI-Driven CDS Trial Endpoints

Result

- Primary endpoint
  - Time to valve intervention (surgical or transcatheter) vs time to MHT clinic visit within 90 days
  - Study powered to detect a 5% absolute increase in appropriate referrals/interventions
- (Final results pending, endpoints focus on improved timeliness of care)

Clinical Relevance

- Representative of a true AI-driven CDS system that:
  - Moves from passive data storage -> active patient identification + action prompting
  - Integrates real-time clinical data extraction + guideline-based decision support

Source: Batchelor WB, Lindman BR, Coylewright M, et al. A randomized trial evaluating automated notifications for the identification and treatment of aortic stenosis and mitral regurgitation: the ALERT study. J Soc Cardiovasc Angiogr Interv. 2025. doi:10.1016/j.jscai.2025.104040

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Summary of Literature Review

Standalone LLMs currently lack reliability for safe, independent clinical decision-making and require human oversight

Uncertainty-aware AI in partnership with a clinician performs better than clinician alone

NLPs allow for extraction and analysis of clinically relevant knowledge from complex unstructured data

AI-driven CDS offers the potential to enhance patient outcomes by way of augmenting clinician knowledge

Sources:

Li L, Du P, Huang X, et al. Comparative analysis of generative artificial intelligence systems in solving clinical pharmacy problems: mixed methods study. JMIR Med Inform. 2025;13:e76128. doi:10.2196/76128

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Takeaways

Safe AI adoption requires transparent, uncertainty-aware models and strong governance

Human-in-the-loop oversight remains essential to ensure accuracy and safety of AI-driven CDS

AI-driven CDS should be evaluated on how it improves workflow, supports safe decision-making and leads to measurable patient outcomes

Ultimate goal: Use AI as a tool to elevate patient safety and quality of care beyond human effort alone

Sources:

Lester C, Rowell B, Zheng Y, et al. Effect of uncertainty-aware AI models on pharmacists' reaction time and decision-making in aweb-based mock medication verification task: randomized controlled trial. JMIR Med Inform. 2025;13:e64902. doi:10.2196/64902

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  - HCA Healthcare

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Thank you!!

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