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Artificial Intelligence in Pharmacy: From Buzzword to Bedside – Driving Innovation in Practice

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Disclosure

I have a vested interest in or affiliation with a corporate organization offering financial support or grant monies for this continuing education activity or organization that has a specific interest in the therapeutic areas under discussion, as follows (within the last 12 months):

- Member, Health IT Leadership Advisory Panel – Pfizer
- During the preparation of this presentation, I used ChatGPT and Google Gemini to generate some photos for demonstration purposes only. After using this tool/service, I reviewed and edited the content as needed and I take full responsibility for the content of the submission

- AI is evolving rapidly. While today's examples reflect meaningful progress, the field remains highly dynamic. As healthcare professionals, we must continuously evaluate, adapt, and evolve with these technologies to ensure patient care remains safe, ethical, and evidence-based

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Presentation Objectives

1. Describe core concepts of artificial intelligence (AI), machine learning, and generative AI as they relate to pharmacy practice
2. Identify current and emerging applications of AI across health-system, ambulatory, and specialty pharmacy settings
3. Evaluate opportunities and risks associated with AI-driven tools, including ethical, regulatory, and patient safety considerations
4. Apply innovation frameworks to assess and implement AI solutions within their own pharmacy practice environments

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AI is Not New—But this Moment is Different

Figure 1 The hope-hype cycle of artificial intelligence since its inception in the 1950s. AI, artificial intelligence.

Shahin et al., Clin Pharmacol Ther, 2024

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1st Objective

CORE CONCEPTS OF AI

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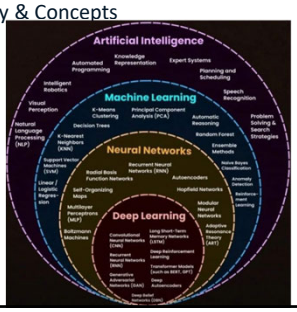
Key Terminology & Concepts

- **Artificial Intelligence (AI):**
  - Machines that mimic human intelligence
  - Reasoning, learning, decision-making
  - Augmenting clinical decision-making and workflow efficiency
- Machine Learning (ML):
  - Subset of AI that learns patterns from data to make predictions
  - Core function: prediction and classification
- Deep Learning & Neural Networks:
  - Advanced ML techniques using layered models for complex pattern recognition
- Generative AI (GenAI):
  - Creates new content (text, summaries, recommendations)
  - Powered by Large Language Models (LLMs)



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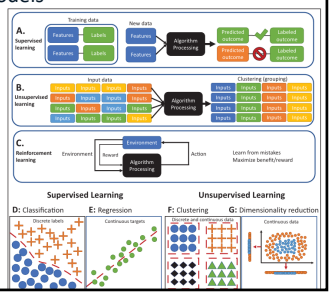
ML Models

- ML Models in Pharmacy
- Supervised Learning
  - Predict known outcomes (e.g., ADE risk, readmission)
- Unsupervised Learning
  - Identify hidden patterns (e.g., patient clustering, utilization patterns)
- Reinforcement Learning
  - Learns optimal actions over time (emerging in treatment optimization)
- Key Concepts:
  - Features = patient variables
  - Labels = outcomes
  - Model = relationship between the two



Nelson et al., Am J Health-Syst Pharm, 2020
Beam and Kohane, JAMA, 2018

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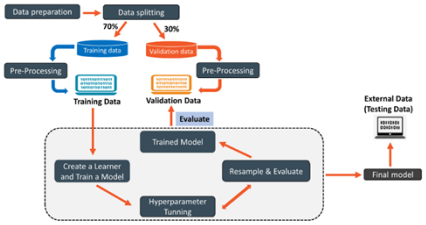
How Machine Learning Actually Works

- Train → Validate → Test
- Model learns patterns from data
- Performance depends on data quality
- **Garbage in, garbage out**



Shahin et al., Clin Pharmacol Ther, 2024

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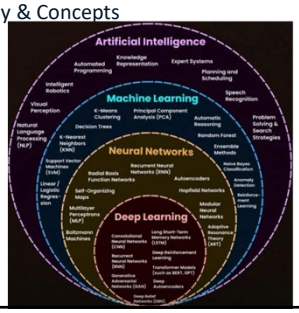
Key Terminology & Concepts

- Generative AI – What's Actually New?
- Traditional AI:
  - Analyzes and predicts
- Generative AI:
  - Interprets, summarizes, creates
- Capabilities:
  - Clinical summarization
  - Natural language interaction
  - Drafting recommendations
- Limitation:
  - Not inherently "truth-based" → requires validation



EITC, AI, Machine Learning, Deep Learning, and Neural Networks
Singhal et al., Nature, 2023

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Key Terminology & Concepts

- From Models to Practice
- ML → Prediction
  - "Which patient is at risk?"
- GenAI → Interpretation
  - Plausible explanations "What might explain their risk?"
- Agentic AI (emerging) → Action
  - "What should we do next?"

Park et al., Proc ACM UIST, 2023
Singhal et al., Nature, 2023

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AI Agent & Agentic AI

- **AI Agent**
  - A software system that performs tasks autonomously based on rules or learned patterns
  - It may respond to input or operate in a defined environment
  - Reactive
  - A clinical tool that flags a high A1c value and suggests guideline-based adjustment
- **Agentic AI**
  - A more advanced AI system capable of autonomous goal setting, long-term planning, and decision-making
  - Can break down complex objectives into sub-tasks
  - Often includes multi-agent collaboration, memory, and reasoning capabilities
  - Proactive and context-aware
  - A virtual assistant: identifies uncontrolled diabetes ----> retrieves past lab trends ----> suggests individualized interventions ----> drafts a communication for the patient ----> schedules a follow-up lab—all proactively

Sapkota et al., arXiv, 2025
Park et al., arXiv, 2023
Lisowski, Medium, 2024
FIP, AI Toolkit for Pharmacy, IPU

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•Singhal, K et al. Nature. 2023.

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Key Takeaway

- AI is not one tool—it is a spectrum
- Most current tools = ML (prediction)
- New tools = GenAI (interpretation + communication)
- Future = Agentic AI (workflow integration + action)

Topol, Nat Med, 2019
Singhal et al., Nature, 2023

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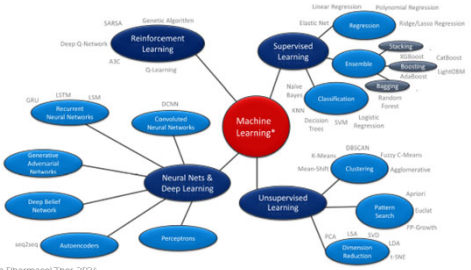
AI Is Broad



Shahin et al., Clin Pharmacol Ther, 2024

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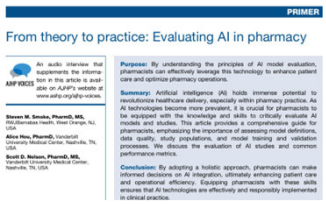
Continue Your AI Journey

- Understanding model design, data quality, and evaluation is essential for safe use
- Not all AI tools add value — critical appraisal is important
- Continuous learning is key as AI rapidly evolves in healthcare
- **Recommended Reading:** *"From Theory to Practice: Evaluating AI in Pharmacy" (AJHP, 2025)*


PRIMER

From theory to practice: Evaluating AI in pharmacy

Smoke et al., Am J Health-Syst Pharm, 2025

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2nd Objective

CURRENT AND EMERGING APPLICATIONS OF AI

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From Concepts to Clinical Impact: Where AI Fits in Pharmacy

- Prediction
  - Risk stratification
  - Workload forecasting
  - Patient prioritization
- Interpretation
  - Chart summarization
  - Message drafting
  - Documentation support
- Action
  - Workflow routing
  - Task automation
  - Escalation to pharmacist review
- Across settings
  - Health-system: medication safety, CDS, operations
  - Ambulatory: documentation, inbox, prior auth, patient messaging
  - Specialty pharmacy: patient identification, refill management, adherence, safety dashboards

ASHP Practice Advancement Initiative 2030, Am J Health-Syst Pharm, 2020
Galanou Luchen et al., Am J Health-Syst Pharm, 2024
Smoke et al., Am J Health-Syst Pharm, 2025

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AI for Clinical Decision Support and Medication Safety

- Predictive models can support:
  - Delirium risk
  - Adverse event risk
  - Pharmacist review prioritization
- Embedded AI can move CDS from "more alerts" to better-targeted alerts
- Best use case: high-risk populations with clear workflows for intervention
  - Leveraging AI to reduce use of deliriogenic medications
    - Delirium detection ↑ fourfold (4.4% → 17.2%)
    - Use of high-risk meds (e.g., benzodiazepines, antipsychotics) ↓

ASHP, Mount Sinai AI Case Study. (2025)
Friedman et al., JAMA Netw Open, 2025

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AI for Pharmacist Prioritization

- Emerging use case: prioritizing pharmacist care using AI
  - 13,373 ICU patients analyzed
  - Avg 4.7 interventions per patient
  - ~10% increase in interventions per unit rise in severity/complexity scores
- Potential applications:
  - ICU patient prioritization
  - Staffing allocation
  - Workload modeling
- Important lesson:
  - AI should support prioritization, not replace clinical judgment

Zhao et al., JAMIA Open, 2025

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AI for Workflow Automation

- Operational AI applications:
  - Fax classification
  - Duplicate detection
  - Routing and labeling
  - Queue management
  - 19,000 + faxes processed within the first month
  - 150+ duplicate faxes removed
- High value for technicians and support staff
- Frees pharmacists and technicians for higher-value clinical and operational work

ASHP. UCSF Health AI Case Study. (2025)

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Ambient Documentation and Visit Efficiency

- AI is increasingly used to support:
  - Visit documentation
  - Note drafting
  - Summarization
- Main value:
  - Less documentation burden and more patient-facing time
  - Burnout decreased from 51.9% to 38.8%
  - Significant improvements in
    - Cognitive task load
    - Time spent documenting after hours
    - Focused attention on patients
    - Urgent access to care

Stults et al., JAMA Netw Open, 2025
You et al., JAMA Netw Open, 2025
Duggan et al., JAMA Netw Open, 2025
Meeker et al., JAMA Netw Open, 2025

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Inbox, Patient Messages, and Prior Authorization

- Current applications:
  - AI-drafted patient message replies
    - Reductions in burden and burnout score derivatives
    - There was no change in time
  - Message categorization / triage (emerging)
  - Administrative support for prior authorization
- Best-fit tasks:
  - Low-risk first drafts
  - Administrative extraction
  - Clinician review before sending

Garcia et al., JAMA Netw Open, 2024
Sahni et al., Health Aff Scholar, 2024

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AI in Drug Information: Promise vs Reliability

- Generative AI is increasingly used for:
  - Drug information questions
  - Dosing guidance
  - Clinical summaries
- AJHP 2026 evaluation of 4 AI tools:
  - Significant variability in accuracy
  - Inconsistent dosing recommendations
  - Potential for clinically relevant errors
- AI can assist—but cannot replace pharmacist verification

Surbaugh LA et al. AJHP. 2026

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Where AI Creates the Most Value

- High-value zones:
  - High-volume, repetitive workflows
  - Structured data and clear rules
  - Need for prioritization (e.g., high-risk patients)
- Low-value zones:
  - Complex, individualized clinical decisions
  - Poorly defined workflows
  - Context-dependent judgment is required

Topol, Nat Med, 2019
Sendak et al., npj Digit Med, 2020

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What Is Current vs Emerging?

- Current
  - Risk stratification
  - Workflow automation
  - Ambient documentation
  - Message drafting
  - Dashboards and refill workflows
- Emerging
  - Workload prediction
  - Agentic task orchestration
  - AI-supported population management at scale
  - More integrated, cross-setting medication-use workflows

ASHP Practice Advancement Initiative 2030, AJHP, 2020
Galanou Luchen et al., AJHP, 2024
Smoke et al., AJHP, 2025

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3rd Objective

OPPORTUNITIES AND RISKS ASSOCIATED WITH AI-DRIVEN TOOLS

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Balancing Opportunity and Risk

- AI can improve:
  - Prioritization
  - Documentation
  - Workflow efficiency
  - Medication safety
- But adoption without oversight can introduce:
  - Bias
  - Hallucinations
  - Privacy risks
  - Unsafe automation
- Core principle: we should evaluate AI as a clinical tool, not just a technology tool

Bastow et al., Am J Health-Syst Pharm, 2025
Mehta, Am J Health-Syst Pharm, 2026
Edwards et al., Am J Health-Syst Pharm, 2025

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The Opportunity Side: Where AI Can Help

- High-opportunity areas:
  - Alert optimization
  - Message drafting
  - Documentation support
  - Refill and fax workflows
  - Patient prioritization
- Best initial use cases:
  - Repetitive, high-volume, low-complexity tasks
  - Tasks with a clear human review step
- Strongest value proposition:
  - Reduce burden while preserving clinical judgment

Graafsma et al., J Am Med Inform Assoc, 2024
Edwards et al., Am J Health-Syst Pharm, 2025
Garcia et al., JAMA Netw Open, 2024

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Patient Safety Opportunity: Better Targeting, Less Noise

- AI can help move CDS from:
  - Broad alerts
  - Interruptive overload
  - Low specificity
- Toward:
  - Better prioritization
  - Fewer low-value interruptions
  - More clinically relevant signals
- Potential to reduce alert fatigue and focus attention

Graafsma et al., J Am Med Inform Assoc, 2024

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Risk: Hallucinations, Omissions, and Wrong Content

- Generative AI can produce:
  - Plausible but incorrect answers
  - Omitted details
  - Overconfident wording
- Errors may involve:
  - Dose
  - Route
  - Frequency
  - Patient-specific contraindications
- Rule: AI-generated medication content should not be used without human verification

Topaz et al., npj Digit Med, 2025
Asgari et al., npj Digit Med, 2025
Anderson et al., Mayo Clin Proc Digit Health, 2025

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AI Can Reduce Errors, Only When Carefully Designed

- AI is not only a source of risk
- It can also reduce medication-related harm
- Example:
  - LLM-supported medication direction tools
  - Clearer, more standardized prescription instructions
- LLMs, with domain expertise and safeguards, improve the accuracy and efficiency of pharmacy operations

Pais et al., Nat Med, 2024
Kim et al., medRxiv, 2025

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Ethical Risk: Bias and Unequal Performance

- AI can be biased even when race is not explicitly used
- Sources of bias:
  - Poor proxy outcomes
  - Unrepresentative training data
  - Unequal access patterns baked into data
- Risk scores may under-identify patients who most need medication support
- AI performance can degrade over time (model drift) or fail to generalize beyond training data (overfitting)

Obermeyer et al., Science, 2019

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Ethical and Operational Risk: Over-trust and Automation Bias

- Users may over-trust polished AI output
- Risks include:
  - Accepting incorrect recommendations
  - Failing to verify source data
  - Bypassing pharmacist review
- AI should support clinical judgment, not displace it

Shekar et al., NEJM AI, 2025
Bastow et al., Am J Health-Syst Pharm, 2025

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Regulatory Considerations: FDA and ONC Matter to Pharmacy

- FDA
  - Regulates some AI tools as software as a medical device
  - Emphasizes lifecycle oversight and Good Machine Learning Practice
- ONC
  - Requires more algorithmic transparency for certain certified health IT decision support interventions
- Not every AI tool is regulated the same way
- Local governance still matters

FDA, AI/ML-Based SaMD Action Plan, 2021
FDA, Artificial Intelligence in Software as a Medical Device, 2025
ONC, HTI-1 Final Rule and DSI Resources, 2023

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Privacy, Data Governance, and Cybersecurity

- Key questions before deployment:
  - Where does the data go?
  - Is PHI retained or used for model training?
  - What vendor controls exist?
  - What is the fallback during downtime or cyber events?
- Generative AI may expand privacy and security exposure if used casually outside approved platforms

HHS, OHRP, The Evolving Landscape of Human Research with AI, 2024
NCVHS, 2024 Report to Congress

HHS, Social Engineering Attacks Targeting the Health and Public Health Sector, 2024
NIST, Cybersecurity Framework 2.0, 2024

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AI is Advancing Very Fast

AI Prescribing (Utah / JAMA)

- AI prescribing medications without physician oversight
- Expanding to ~200 drugs
- Limited transparency and independent validation
- Challenges:
  - Licensing
  - Accountability
  - Regulatory alignment

Patient-Facing AI (RecovryAI)

- LLM interacting directly with patients
- Influences understanding and care decisions
- Accelerated regulatory pathway (FDA Breakthrough)
- Risks:
  - Misinformation / hallucination
  - Over-trust
  - Unmediated clinical impact

AI is moving into high-impact clinical roles faster than our ability to govern it safely

Aaron and Robertson, JAMA, 2026
RecovryAI, FDA Breakthrough Device Designation Announcement

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Bottom Line

- Ask four questions before adopting an AI tool:
  - What problem are we solving?
  - What is the evidence of benefit?
  - What new risks are introduced?
  - Who is accountable for review and monitoring?
- Best stance:
  - Optimistic but skeptical
  - Innovative but disciplined
  - Human-centered and safety-focused

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4th Objective

FRAMEWORKS TO ASSESS AND IMPLEMENT AI SOLUTIONS

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Why Use Frameworks for AI

- AI decisions should not rely on hype or vendor demos alone
- Questions to ask:
  - Is this solving a real problem?
  - Is it safe and trustworthy?
  - Can we implement it in our workflow?
  - Will it be worth sustaining?
- Frameworks turn AI selection into a structured decision

Smoke et al., AJHP, 2025
Bastow et al., AJHP, 2025

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DVF Framework

- Desirability = Do users and patients actually want or need this?
- Feasibility = Can we technically and operationally implement it?
- Viability = Can it be sustained financially and strategically?
- Origin: design thinking / innovation strategy

Dimension	Rating	Meaning
Desirability	🟢 / 🟡 / 🔴	Strong need vs weak
Feasibility	🟢 / 🟡 / 🔴	Easy vs hard to implement
Viability	🟢 / 🟡 / 🔴	Sustainable vs risky

Example:
All green → move forward
Mixed → refine/pilot
Any red → pause or redesign

IDEO, Design Thinking. https://designthinking.ideo.com/
Brown, Harv Bus Rev, 2008

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Why DVF Is Useful

- Helps avoid "technology-first" projects
- Keeps attention on:
  - Patient and clinician need
  - Workflow fit
  - Operational realism
  - Long-term value
- Best used before procurement or pilot launch

Smoke et al., AJHP, 2025
IDEO, Design Thinking. https://designthinking.ideo.com/

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What DVF Does Not Cover Well

- DVF is not enough by itself for health AI
- It does not fully address:
  - Model bias
  - Validation quality
  - Privacy and security
  - Monitoring drift over time
  - Transparency and accountability
- Pair DVF with an AI-specific risk framework

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AI Alone Is Not Enough: Implementation Determines Impact

- Randomized controlled trial: AI-assisted chest X-ray prioritization
  - Faster radiology reporting with AI
  - No improvement in:
  - Time to CT
  - Diagnosis
  - Treatment initiation
- Key findings:
  - High discordance (~30%) between AI and radiologists
  - AI detected some missed findings—but added noise
  - No clear improvement in patient-centered outcomes

Woznitza et al., Nat Med, 2026

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FAIR-AI: Evaluating Trustworthy AI in Healthcare

- FAIR-AI focuses on:
  - **F**airness → Does it work equitably across populations?
  - **A**ccountability → Who is responsible for outcomes?
  - **I**nterpretability → Can we understand how it makes decisions?
  - **R**eliability → Does it perform consistently and safely?
- What It Adds Beyond DVF
  - Deep evaluation of:
    - Model behavior
    - Bias and equity
    - Clinical safety
  - Focus on trustworthiness, not just feasibility
- This matters when AI affects prioritization, recommendations, or patient communication

Wells et al., npj Digit Med, 2025

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Other AI Frameworks to Consider

- Stanford FURM (Foundation Model Risk Management)
  - **F**air, **U**seful, and **R**eliable AI **M**odels
  - Focus on generative AI risks (hallucination, misuse)
- AI Maturity Roadmap
  - Assess organizational readiness and scaling capability
- Multiple frameworks exist—selection depends on use case and organizational needs

Callahan et al., NEJM Catalyst, 2024
Durlach et al., N Engl J Med AI, 2024

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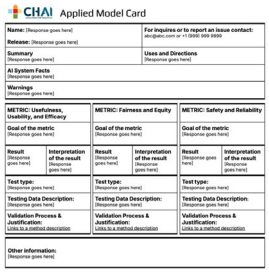
CHAI and the Health AI "Nutrition Label"

- CHAI = Coalition for Health AI
- CHAI's Applied Model Cards are described as health AI "nutrition labels"
- Intended purpose:
  - Simplify procurement
  - Standardize transparency
  - Summarize capabilities, limitations, and testing information
- Useful for health-system AI committees and leaders
- Emerging and not yet universal



CHAI Applied Model Card

Name: [Response goes here]	**For inquires or to report an issue contact:** abc@abc.com or +1 (000) 000 0000
Release: [Response goes here]	
Summary [Response goes here]	**Uses and Directions** [Response goes here]
AI System Facts [Response goes here]	
Warnings [Response goes here]	

METRIC: Usefulness, Usability, and Efficacy		METRIC: Fairness and Equity		METRIC: Safety and Reliability	
Goal of the metric [Response goes here]		**Goal of the metric** [Response goes here]		**Goal of the metric** [Response goes here]	
Result [Response goes here]	**Interpretation of the result** [Response goes here]	**Result** [Response goes here]	**Interpretation of the result** [Response goes here]	**Result** [Response goes here]	**Interpretation of the result** [Response goes here]
Test type: [Response goes here]		**Test type:** [Response goes here]		**Test type:** [Response goes here]	
Testing Data Description: [Response goes here]		**Testing Data Description:** [Response goes here]		**Testing Data Description:** [Response goes here]	
Validation Process & Justification: Links to a method description		**Validation Process & Justification:** Links to a method description		**Validation Process & Justification:** Links to a method description	

Other information: [Response goes here]

CHAI, Health AI "Nutrition Label" Advances, 2025
CHAI, Assurance Lab Certification & "Nutrition Label", 2024

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Applying AI Frameworks in Pharmacy Practice

- Now let's apply DVF, FAIR-AI, and CHAI
- Hypothetical Case example:
  - AI-supported digital refill triage in a health-system specialty pharmacy
  - Digital questionnaire via patient portal
  - Captures adherence, effectiveness, and barriers
  - Pharmacist escalation for flagged responses
  - Intended goals:
    - Reduce technician workload
    - Improve refill efficiency
    - Preserve pharmacist review for complex cases

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Applying AI Frameworks in Pharmacy Practice

- **Using DVF:**
  - Desirability: Addresses real pain point (refill burden, adherence gaps)
  - Feasibility: Fits within patient portal + existing workflow
  - Viability: Demonstrated workload reduction and scalable model
- **Using FAIR-AI:**
  - Fairness: Requires monitoring across patient populations (portal access, literacy)
  - Accountability: Maintains pharmacist oversight for flagged cases
  - Interpretability: Transparent logic (questionnaire-based, not black-box)
  - Reliability: Performance depends on response quality and escalation pathways
- **Using CHAI concept:**
  - Would benefit from standardized reporting of:
    - Validation approach
    - Limitations (non-response bias, digital access)
    - Performance metrics

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Practical Take-Home

- Start with the problem
- Use DVF to screen
- Use an AI-specific framework, such as FAIR-AI, to assess trust and risk
- Request a CHAI-style model card / nutrition label
- Pilot and measure
- Scale only if benefits persist and risks are controlled
- Have a plan for monitoring

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Key Takeaway

- Focus on Real Use Cases
- Balance Opportunity with Responsibility
- Understand the Technology
- Use Frameworks to Lead Implementation
- Artificial Intelligence

AI will not replace pharmacists—
Pharmacists who understand AI will lead those who don't

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Prompt: Draw a group of watches showing 3 minutes after 12

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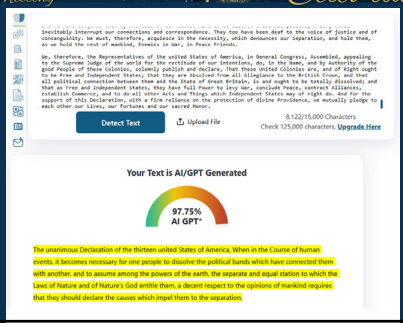
Declaration of Independence



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The Rise and Fall of Multiplane Camera

Used to give a sense of depth and realness to classic animated films - The Little Mermaid

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Questions?

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Artificial Intelligence in Pharmacy: From Buzzword to Bedside – Driving Innovation in Practice

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Thank you!

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