Future of Health:

The Emerging Landscape of Augmented Intelligence in Health Care

Research collaboration led by manatt

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The American Medical Association is the powerful ally of and unifying voice for America's physicians, the patients they serve, and the promise of a healthier nation. The AMA attacks the dysfunction in health care by removing obstacles and burdens that interfere with patient care. It reimagines medical education, training, and lifelong learning for the digital age to help physicians grow at every stage of their careers, and it improves the health of the nation by confronting the increasing chronic disease burden. For more information, visit ama-assn.org.

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Contributors

The authors wish to acknowledge and thank all of the organizations and individuals who generously offered their time and expertise to this report. Please see the complete list of all contributors and reviewers beginning on page 24.

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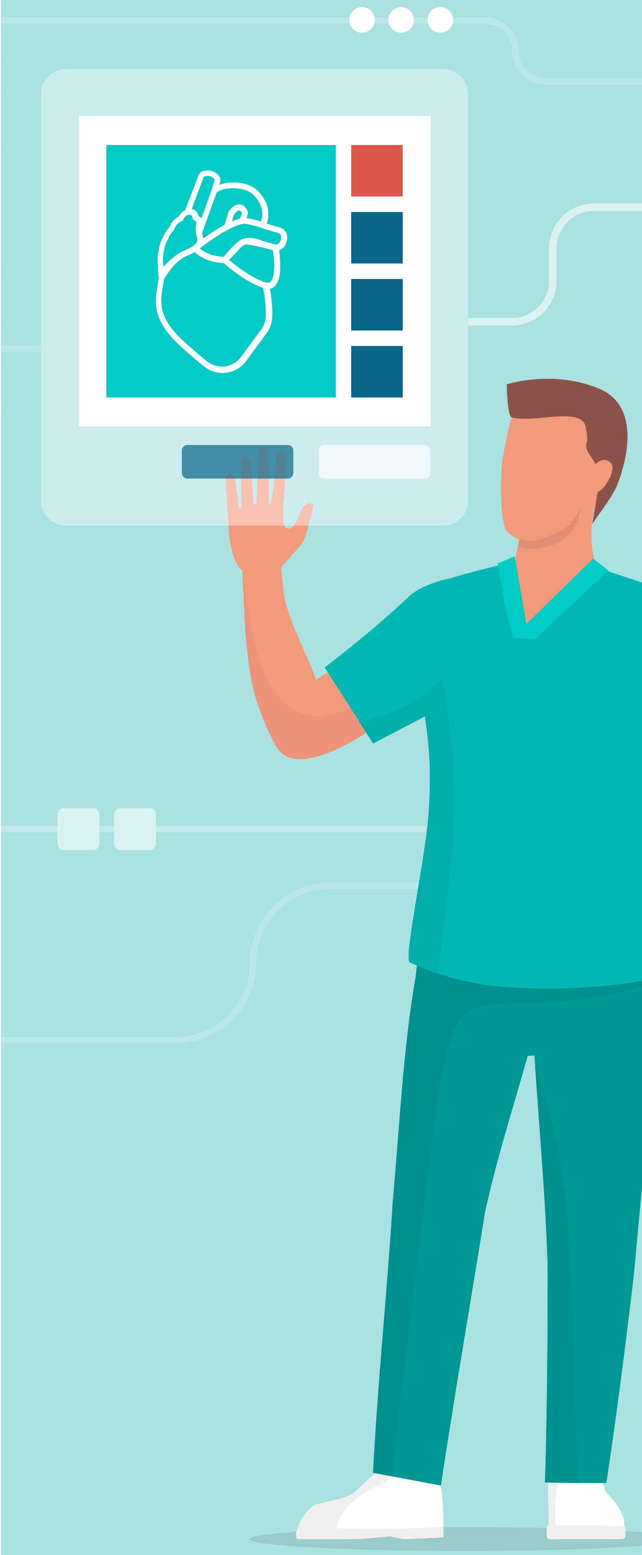
Executive summary

In this comprehensive report, we explore the transformational potential of augmented intelligence (AI) in the practice of medicine and outline practical considerations for physicians who are using or considering using AI-based tools for clinical or administrative purposes. The American Medical Association (AMA) uses the term "augmented intelligence" rather than "artificial intelligence" to reflect its perspective that artificial intelligence tools and services support rather than explicitly replace human decision-making.

AI in health care is not new. The use of AI in medicine dates to the mid-20th century and has been increasingly used in recent years in radiology, cardiology and neurology. Recent technological developments—such as advances in deep learning and the development of foundation models—have dramatically expanded the potential use cases of AI in the delivery and administration of health care. AI models have been used to develop cancer prognoses, respond to patient messages, predict adverse clinical events and recommend optimal staffing volumes. Just last year (2023), an AI large language model algorithm successfully passed the multiple-choice section of the United States Medical Licensing Examination—just one example of AI's vast and rapidly expanding capabilities.

Physicians are at a crossroads: intrigued by the transformative potential of AI to enhance diagnostic accuracy, personalize treatments, reduce administrative burden, and accelerate advances in biomedical science, yet concerned about AI's potential to exacerbate bias, increase privacy risks, introduce new liability concerns, and offer seemingly convincing yet ultimately incorrect conclusions or recommendations. While a majority (65%) of physicians surveyed by the AMA indicated they see definite or some advantage to using AI tools, a similar majority (70%) are either more concerned than excited or equally concerned and excited about the potential increased use of AI in the delivery of medicine.[1] Adapting to an AI-enabled future will necessitate dramatic changes in medical education, practice, regulation and technology.



Through a robust physician survey, a series of interviews with experts in artificial intelligence and a roundtable discussion with specialty society representatives, the AMA identified key AI use cases physicians are utilizing today and likely use cases that will develop in scale and sophistication in the coming years. While there are similarities in use across specialties—documentation support, patient engagement, prediction of adverse clinical outcomes—key differences are also present, based primarily on the unique skills and foci of each specialty, such as emergency medicine's use of AI to monitor vitals and family medicine's prioritization of personalized patient educational materials and medication adherence. Physicians recognize the value of AI in supporting administrative functions as well as clinical tasks, with 56% of those surveyed identifying "addressing administrative burden through automation" as the biggest area of opportunity for AI.[2]

The AMA is committed to ensuring that the evolution of AI in medicine equitably benefits patients, physicians and other health care stakeholders, and intends to continue developing AI principles for the use of AI in health care, advocate for state and federal policies that ensure appropriate oversight and continued innovation in AI, partner with health and technology leaders to ensure physicians have a leading voice in shaping the ethical use of AI in medicine, promote training in AI across the continuum of medical education, and provide high-value insights and actionable resources for physicians.

The AMA developed this report for physicians interested in exploring the potential of AI in health care. It aims to provide an analysis of AI's opportunities and challenges and offer guidance on key considerations for integrating AI-based tools into clinical or administrative practices.

Introduction

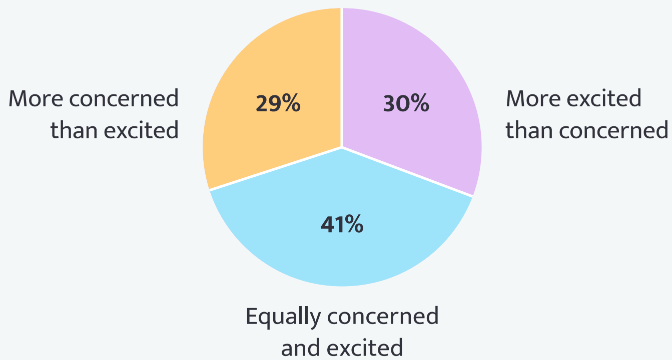
With the growing availability of—and interest in—Augmented Intelligence (AI) applications in health care, the AMA is committed to ensuring physicians have the knowledge and tools to successfully navigate an AI-enabled future. The AMA uses the term "augmented intelligence" in lieu of "artificial intelligence" to reflect its perspective that artificial intelligence tools and services support rather than explicitly replace human decision-making.[3] For the purpose of this report, AI refers to augmented intelligence.

AI in health care is not new. First introduced in the mid-20th century, health care AI tools of the time were primarily rules-based algorithms that relied on human-defined logic to produce outputs. Fifty years later, the use of more sophisticated predictive models became increasingly common across health care, due in part to larger data availability and more affordable computing power. More recently, generative artificial intelligence models—algorithms that can process enormous, unlabeled, and multimodal data sets (image, text, video)—are being heralded as the next frontier of AI in medicine and society at large.

As medical knowledge grows, the volume of health data expands, and technologies improve, tools have the potential to support physician workflows and decision-making.[4] The use cases for AI tools in health care are vast and include both clinical and administrative activities, such as summarizing medical notes, detecting and classifying the likelihood of future adverse events, or predicting patient volumes and associated staffing needs. The regulatory landscape for AI, which was previously limited at both the federal and state levels, is seeing a significant uptick in activity aiming to guide the development, testing, implementation, and monitoring of AI tools and services. Physicians, technology developers, clinical leaders, and regulators must work together to effectively balance the immense potential of these tools with appropriate oversight and guidance.

Although physicians recognize AI's advantages—65% of physicians surveyed by the AMA indicated they see definite or some advantage to using AI tools—overall, physicians are cautious in their optimism: 30% of respondents are more excited than concerned, 29% are more concerned than excited, and the remaining 41% are equally concerned and excited (Figure 1).

Figure 1: Physician reactions to potential increased use of AI across health care



This report, jointly developed by the AMA and Manatt Health, aims to explore the promises and risks of AI in health care and provide an overview of the key concepts, use cases, and challenges physicians should be aware of as AI tools and their use grow across the industry. This report also highlights the AMA's commitment to advancing the safe, effective, transparent and equitable use of AI tools and services through the development of AI principles, advocacy for appropriate federal and state regulations and oversight, and physician education. The findings and opportunities featured in this report were gathered through a survey of over 1,000 physicians, a series of interviews with artificial intelligence experts, a roundtable discussion with specialty society representatives (see Acknowledgements), and a review of existing literature about health AI.[5,6,7,8]

Key concepts and definitions

"Artificial intelligence" broadly refers to the ability of computers to perform tasks that are typically associated with a rational human being—a quality that enables an entity to function appropriately and with foresight in its environment.[9]

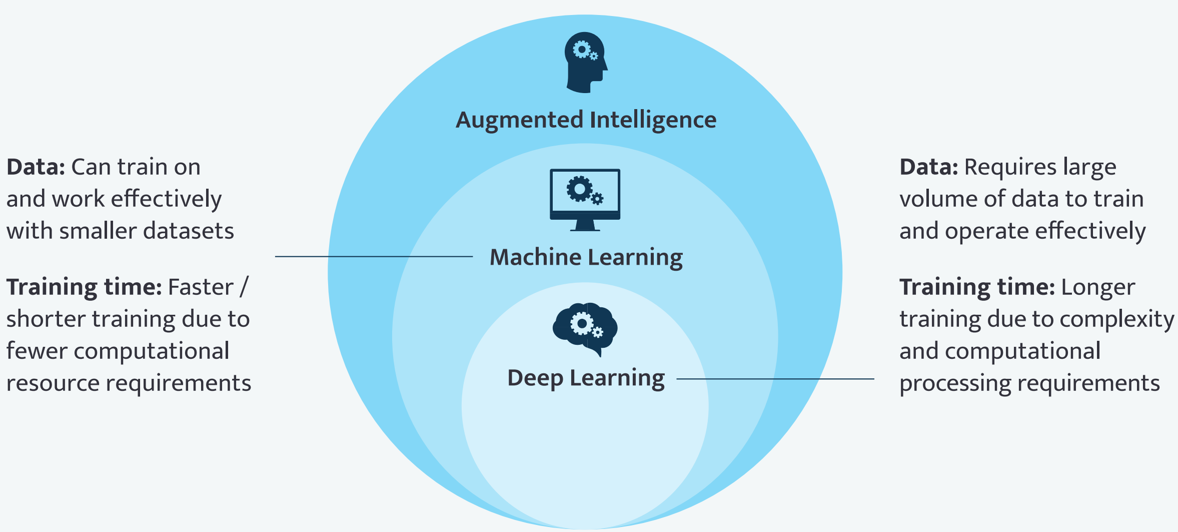
"Augmented intelligence" (AI) is an alternative conceptualization that focuses on artificial intelligence's assistive role, emphasizing the fact that AI design enhances human intelligence rather than replaces it.

AI terminology can describe both how an AI system works and what the AI system does.

- **How a system works**. AI algorithms work in a myriad of ways, including having a predefined logic and reasoning ("rules-based learning"), learning from patterns in data ("machine learning"), or using multi-layered "neural networks" modeled on the human brain that extract complex patterns from input data ("deep learning"), among others.
- **What a system does.** AI applications are as varied as the algorithms themselves, with functionality that includes deriving information from images or videos ("computer vision"); deriving information from text ("natural language processing" and "large language models"); and producing new and original content ("generative artificial intelligence") such as creating text ("large language models") or images ("image generators"), among others.

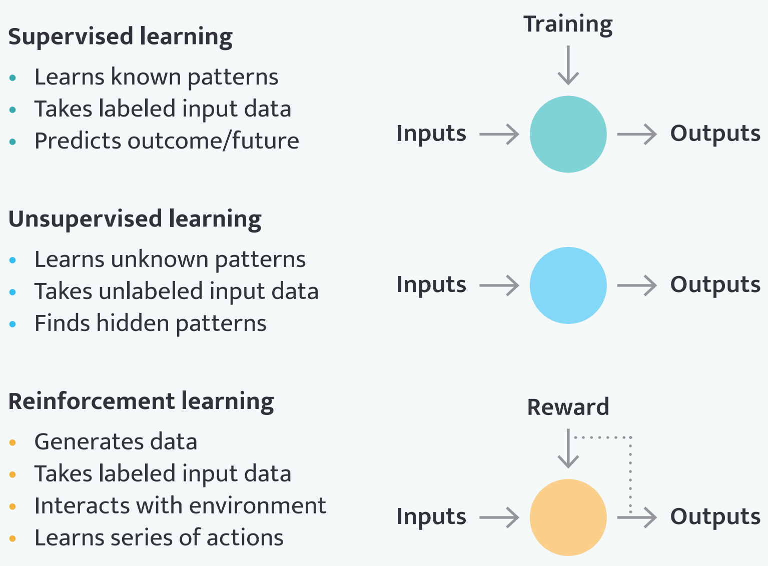
AI, machine learning and deep learning are distinct but related terms (Figure 2). Machine learning, a subtype of AI, describes systems that learn from data without being explicitly programmed. Deep learning, a subtype of machine learning, refers to systems that train themselves by processing data and information in a manner similar to the neural pathways of the human brain.

Figure 2: Relationship between AI, machine learning, and deep learning[10]



There are three fundamental techniques for training machine learning models: supervised learning, unsupervised learning and reinforcement training (Figure 3). Supervised learning trains algorithms on labeled data; that is, each data input is associated with a corresponding target or output. The goal of supervised learning is to train an algorithm to identify specific patterns such that the algorithm can make accurate predictions on new and novel data. Unsupervised learning trains algorithms with unlabeled data. The goal of unsupervised learning is to train an algorithm to identify and discover unknown patterns and relationships within data. Finally, reinforcement learning involves a feedback loop, where the algorithm is fed labeled data ("inputs") and, based on actions the algorithm takes with that data (i.e., makes a prediction about X given Y), creates an "output." The algorithm receives a reward when its action and output align with the goals of the programmer. Thus, as the name implies, an algorithm trained via reinforcement is rewarded ("reinforced") when its behavior aligns with the desired action.

Figure 3: Machine learning training techniques



Source: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6542626/

Generative Artificial Intelligence

Public awareness of artificial intelligence shifted significantly in 2023 with the introduction of generative artificial intelligence models, led by Open AI's ChatGPT, which reached 1 million users within five days of launch. Generative artificial intelligence has the potential to rapidly transform the healthcare sector, including assisting with diagnoses, automating note generation from patient visits, and drafting responses to patient messages. But the technology also brings risks—discussed later in this report—such as bias, limited explainability, hallucinations, and privacy and security concerns.

Term	Definition
Algorithm	A set of rules or commands that a computer follows to perform calculations or other problem-solving operations.
Artificial intelligence	The ability of computers to perform tasks that are typically associated with a rational human being—a quality that enables an entity to function appropriately and with foresight in its environment.
Augmented intelligence (AI)	Computational methods and systems that enhance human capabilities and decision-making.
Bias	Prejudices in favor of or against a person, thing, or entity. Different types of bias in AI include the following: • **Algorithm bias** occurs when there is an underlying problem or flaw with the algorithm used to deliver outputs. • **Data bias** occurs when the data used to train AI systems is biased in some way. Some examples of data bias include: o **Exclusion bias** occurs when critical data point(s) are excluded from the training dataset. o **Measurement bias** occurs when there are issues with the accuracy or precision of the training data. o **Prejudice bias** occurs when the data used to train the algorithm contains prejudices or faulty societal assumptions. o **Sample bias** occurs when the data used to train the model is not representative of the population for which the tool will be used. • **Reliance bias** occurs when humans over- or under-rely on AI models to inform decisions or actions.
Black box	The inability of a user to understand the specific steps taken by an algorithm that lead to an algorithm's final output.
Deep learning	A subtype of machine learning that describes algorithms that operate on multi-layered "neural networks" modeled on the human brain. Deep learning algorithms can extract complex patterns from input data.
Federated learning	A decentralized approach to training machine learning models; rather than aggregating all data together, federated learning uses local devices with local data to train algorithms.
Foundation models	Models that are trained on large datasets—and thus broadly applicable—and can be adjusted for specific applications. Typically used for generative artificial intelligence; LLMs are one type of foundational model.
Generative artificial intelligence	Artificial intelligence systems that are capable of generating novel text, images, videos, or other outputs, typically based on foundational models.
Hallucinations	Outputs from an AI model that are nonsensical, misrepresent data from the training dataset, and/or are false.
Large language models (LLMs)	Models that are a subset of generative AI and have the ability to understand and generate human language.
Machine learning	A subtype of AI in which complex algorithms are trained to make predictions about future outcomes. Machine learning can be supervised or unsupervised.
Narrow AI	Algorithms designed to accomplish specific (versus broad) tasks.
Natural language processing (NLP)	An algorithm's ability to interpret and/or translate language.
Neural network	Software constructions utilized in deep learning included in an algorithm that are modeled after the way adaptable neurons in the human brain function.
Reinforcement learning	A machine learning training method that uses rewards and punishments to teach desired and undesired behaviors as part of model training.
Supervised learning	A training technique used to train machine learning models. Supervised learning trains algorithms with labeled data.
Unsupervised learning	A training technique used to train machine learning models. Unsupervised learning trains algorithms with unlabeled data.

Opportunities and use cases

A range of health care AI capabilities are emerging which, independently and in concert, will have a significant impact on health care delivery. Several of these capabilities (Table 1), such as prediction and identification, have been in practice for many years, while others, such as translation and summarization, are more recent additions to the AI landscape with the introduction of large language models.

Table 1: AI capabilities.

AI capability	Description	Example clinical scenario	Potential role of AI
Identification	Identifying objects, patterns, and/or characteristics within data (often images).	A physician orders an X-ray for a patient who presents with pain, swelling, and limited leg mobility.	An AI tool reviews the X-ray and identifies an incidental nodule for further analysis by a radiologist.
Translation	Translating data inputs into another data type or data format (often between modalities or languages), often using natural language processing.	A radiologist reviews an MRI for a patient at-risk of breast cancer and dictates observations via an audio recording.	An AI tool converts the radiologist's audio dictation into a structured summary and applies the BIRADS classification scheme automatically. The AI produces a 'plain language' interpretation for the patient. The AI could also translate the report into a different language.
Summarization	Summarizing data inputs into shorter and more accessible outputs.	A patient is admitted to an emergency department in status epilepticus. A team of admitting health care professionals review the patient's medical file to understand the patient's medical history, current medications, previous allergic reactions and potential triggering factors.	An AI tool reviews the patient's medical history in totality, near-instantly identifying and summarizing key information for current clinical needs, such as recent medication changes affecting seizure threshold and a list of contraindicated drugs based on allergy history.
Prediction	Predicting or forecasting future events based on historical data and patterns.	A patient is discharged after hospitalization for heart failure. A patient is discharged after hospitalization for heart failure.	Using historic heart failure readmission rates and the patient's clinical data, an AI tool predicts the risk of the patient's hospital readmission.
Suggestion	Providing recommendations, guidance or advice. In some systems, suggestions may automatically lead to a specific downstream action.	A patient sees a provider every few months for a routine check-in; clinical team conducts retrospective analysis of blood glucose measures from the past few months.	An AI tool continually monitors a patient's blood glucose levels and (1) sends an alert to patient and clinician when deviations occur and (2) provides recommended course of action (e.g., insulin level recommendation).

Historically, certain specialties have utilized AI more than others. As of October 2023, the U.S. Food and Drug Administration (FDA) has approved 692 artificial intelligence/machine learning medical devices, of which 531 are in radiology, 71 are in cardiology, and 20 are in neurology.[11]

Today, there is significant interest in implementing AI tools into practice: 65% of physician respondents in the AMA's 2023 AI Physician Survey agree that there is some or definite advantage to implementing AI tools into clinical settings. The use of AI tools, however, is not pervasive—62% of respondents indicated they do not use a listed set of AI tools[12] in their practice today (Figure 4).[13] Table 2 outlines select clinical use cases of AI across specialties today and potential uses in the future.

Figure 4: AMA 2023 AI Physician Survey: Current use cases across specialties

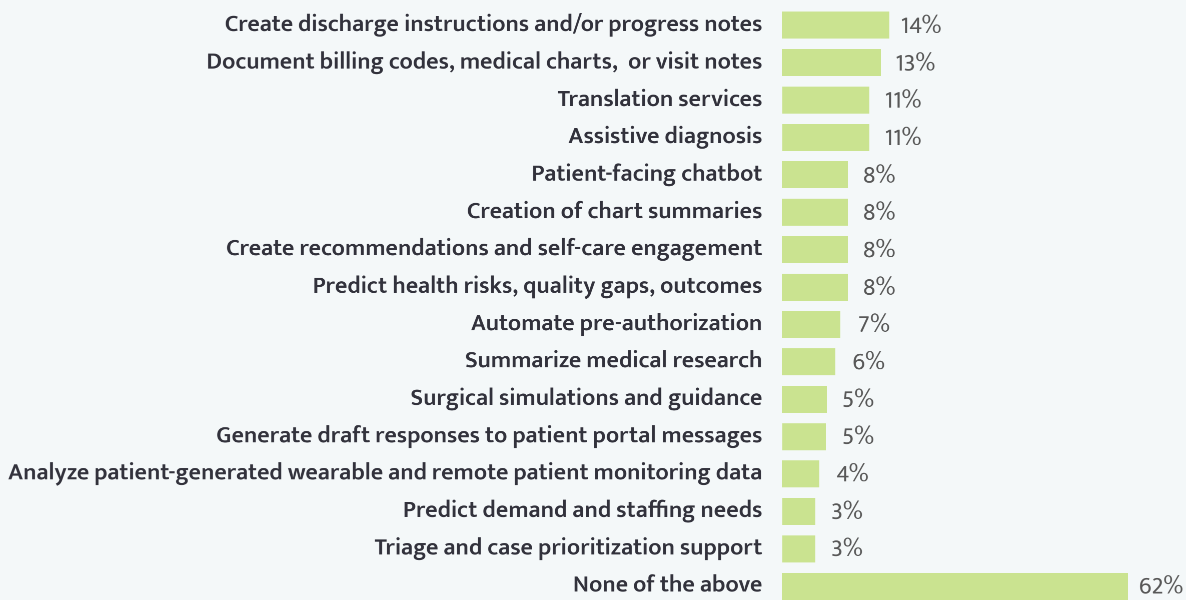


Table 2: Select clinical AI use cases across specialties.

This table provides a select, non-exhaustive snapshot of use cases across AI specialties today and potential future use cases, informed by interviews with experts in artificial intelligence and a roundtable of specialty society representatives.

Clinical use cases		
Specialty	**Example AI use cases in practice today**	**AI use cases in the future (or currently in use, but not at scale)**
All specialties	• Real-time clinical transcription. • Answer routine patient questions via chatbots. • Draft personalized patient education materials based on patient history and chart review. • Predict adverse clinical outcomes based on vitals and/or other markers.	• Draft responses to patient in-basket communications. • Convert open-ended clinical notes and data (e.g., dictation, long-form text) into an electronic health record (EHR) format and codify medical information into standardized terminology. • Support patient triage based on severity of symptoms.

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Clinical use cases		
Specialty	**Example AI use cases in practice today**	**AI use cases in the future (or currently in use, but not at scale)**
Cardiology	• Detect arrhythmias, ischemia and other heart abnormalities through electrocardiogram (ECG) analysis. • Predict fractional flow reserve (FFR) from computed tomography (CT) images to aid in assessment of coronary artery disease. • Use guidance during echo image analysis to optimize views and enable upskilling of practitioners. • Triage data from remote patient monitoring devices (e.g., wearable sensors) and electronic health record (EHR) systems to identify patients at highest risk for disease progression.	• Triage data from imaging and electronic health record (EHR) system for early diagnosis and referral. • Utilize ECG to assess progression of valvular disease. • Assess personalized risk factors most strongly influencing cardiovascular outcomes for modification.
Dermatology	• Identify malignant melanomas through image analysis. • Predict likelihood, and assess severity, of psoriasis.	• Increase accuracy of melanoma and other skin cancer detection at earlier stages with advanced imaging classification. • Develop personalized treatment options and skin regimens based on patient's skin condition, genetics and environmental factors.
Emergency medicine	• Monitor patient vital signs and predict decompensation based on vital-sign trends. • Augment triage of patients based on review of current patient clinical condition and medical history. • Analyze images to accelerate time to treatment (e.g., identification of patients with suspected critical findings admitted to the ED for acute stroke).	• New capabilities for facilitating the performance and interpretation of point of care (POC) ultrasound. • Automate real-time prediction of optimal therapy for individual patients.
Family medicine	• Monitor blood pressure via connected devices and alert patient's care team when deviations occur. • Support patient engagement and education through AI-driven chatbots and symptom checkers that answer foundational questions about health.	• Support medication adherence by monitoring patients and sending alerts to both patients and providers. • Develop novel remote physiologic monitoring capabilities that provide passive and real-time remote sensing of disease onset or progression.
Neurology	• Analyze electroencephalography (EEG) studies to identify neurophysiological abnormalities and/or define the origin of seizures in the brain. • Detect and locate cerebrovascular abnormalities (e.g., ischemia) through continuous EEG analysis. • Analyze sleep polysomnography (PSG) to categorize sleep stages. • Identify stroke risk through the analysis of imaging data.	• Analyze multi-modal wearable data to predict, detect, and classify epileptic seizures. • Analyze multiple sources of data to identify early biomarkers of neurodegenerative diseases (e.g., Alzheimer's, Parkinson's). • Triage data from remote patient monitoring devices (e.g., wearable sensors) to identify patients at the highest risk for brain injuries and post-brain injury complications.
Obstetrics and gynecology	• Automatically analyze obstetric ultrasound imaging for potential fetal anomalies. • Optimize embryo selection during in vitro fertilization (IVF).	• Personalize birth and treatment plans based on medical history, fetal experience and vitals. • Automatically detect risk of postpartum hemorrhage hours in advance for all patients.
Ophthalmology	• Screen for and identify diabetic retinopathy through analysis of retinal imaging. • Detect glaucoma through analysis of visual field tests and optical coherence tomography (OCT) scans. • Quantify fluid on optical coherence tomography scans.	• Autonomous screening and assistive diagnosis of all common forms of blindness through fundus images or OCT scans. • Predict cardiovascular and neurological risk factors through analysis of retinal fundus photographs.

Clinical use cases		
Specialty	**Example AI use cases in practice today**	**AI use cases in the future (or currently in use, but not at scale)**
Pathology	• Identify biomarkers (e.g., cancer detection through tissue sample analysis) and suggest diagnosis. • Conduct quality control on pathology laboratory processes (e.g., identify staining artifacts).	• Assist in sample (e.g., blood smear) diagnosis. • Standardize quantification tasks (e.g., tumor protein expression quantification and treatment recommendation).
Pediatrics	• Monitor patient vitals to detect deviations and anticipate onset of critical illnesses (e.g., sepsis). • Analyze patient's medical history and other inputs such as vitals, images, videos, etc., to predict disease (e.g., autism spectrum disorder).	• Detect developmental delays in infants and children through analysis of video, speech, and/or written data. • Predict risk of acute illness (e.g., pneumonia) earlier than current practice through X-ray analysis.
Radiology	• Detect and classify features on imaging exams (e.g. fracture, stroke, brain hemorrhage, lung nodules etc.). • Automate triage of imaging exams. • Quantify disease burden (e.g. metastatic disease, tumor response, multiple sclerosis, degeneration, bone density/fracture risk assessment etc.).	• Conduct non-invasive genomic analysis of cancer using imaging phenotypes. • Automate processes (e.g., ordering and protocoling of imaging studies, reporting of routine studies). • Automate image-based response criteria for oncology. • Conduct real-time population health data monitoring based on imaging models.

While AI tools can play a critical role in clinical delivery, they may similarly transform administrative functions: 56% of respondents to the AMA's 2023 AI Physician Survey chose "addressing administrative burdens through automation" when asked to evaluate the biggest area of opportunity for AI (Figure 5).[14] Optimized scheduling, staff management, billing, and general operations are ripe for support from AI solutions; Table 3 outlines key administrative areas in which the AMA has heard physicians express particular enthusiasm.

Figure 5: AMA 2023 AI Physician Survey: Biggest area of opportunity for AI to address

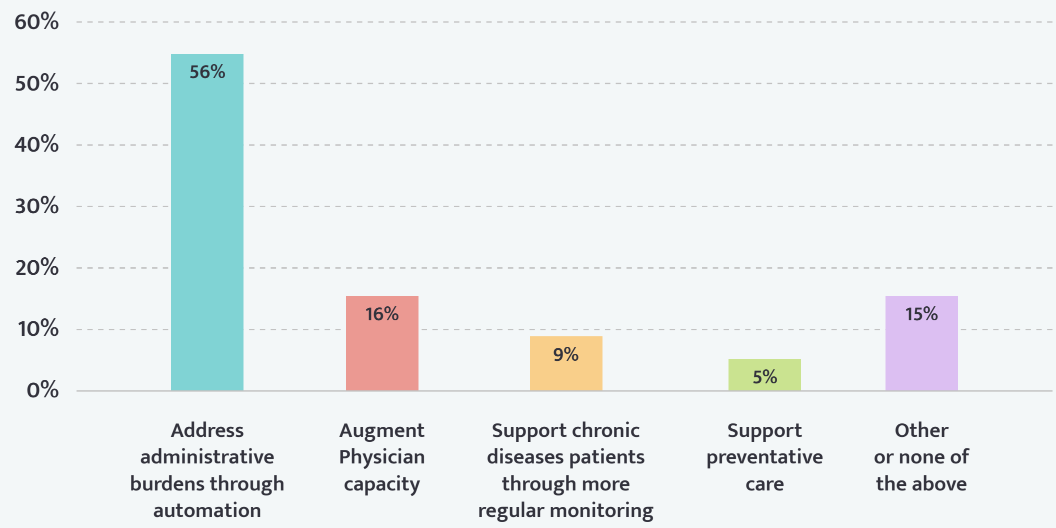


Table 3: Non-clinical AI use cases across specialties

Non-clinical use cases	
Many of these are used to some degree today, and all are likely to see an increase in utilization over the coming decade.	
Access to care	• Identify optimized scheduling to minimize wait times and maximize alignment of patient needs and physician experience. • Support prior authorization process, including completion and follow-up of prior authorization documentation.
Administration and revenue cycle	• Identify appropriate billing and service codes based on medical notes. • Predict likelihood of—and identify opportunities to reduce—claims denials. • Supporting accurate coding in the context of risk-adjustment and value-based payment programs.
Operations	• Predict hospital staffing volumes and requisite staffing needs. • Track inventory and utilization patterns to forecast medical supply orders. • Monitor equipment availability and predict equipment failures.
Regulatory compliance and reporting	• Automate the tracking and reporting of regulatory compliance measures, reducing administrative burden. • Analyze documentation and processes to ensure adherence to evolving health care laws and policies.
Patient experience and satisfaction analysis	• Analyze patient feedback and surveys to identify areas of improvement in patient experience. • Predict patient satisfaction trends and identify drivers of patient trust.
Quality improvement and management	• Automatically track identified quality outcomes and generate reports. • Identify gaps in quality and/or inequities in patient outcomes or services.
Education	• Monitor a clinical interaction with a model patient and provide feedback to the physician or trainee. • Based on review of physician or trainee's experiences and skill sets, identify possible learning needs and/or recommend learning resources. • Provide automated haptic feedback during robotic training.
Research	• Predict the structures of proteins from amino-acid sequence. • Optimize research subject outreach and enrollment in clinical trials. • Analyze electronic health records at scale to identify potential human research subjects.

Challenges and risks

As AI tools evolve, there are a few key challenges and considerations that physicians and health care leaders should be aware of.

Bias

Human biases are well known and well documented, and in health care can affect access to care and patient outcomes. Because AI tools are trained on real-world or human-generated data, there is risk that prejudices or unconscious biases in training datasets will inform an AI model's outputs; this is referred to as "data bias." There are several other types of bias that can be introduced to an AI model—including sample bias, measurement bias, and algorithm bias, among others—each of which has the potential to introduce risk that results in an algorithm that produces inaccurate or potentially discriminatory results. Importantly, these data biases are often due to historical policy choices that resulted in disparate access to different groups and/or encouraged the study of different groups, thereby resulting in the disparate data available today.

Unfortunately, there have been instances of medical artificial intelligence algorithms exacerbating existing social inequities.[15,16,17,18] For example, a recent algorithm disproportionately targeted white patients over Black patients for inclusion in a care management program. Using health costs as a proxy for health needs, the algorithm incorrectly concluded that white patients—who, due to disproportionate access to care, had historically incurred greater costs than their Black counterparts—were more sick than Black patients.[19] Another study showed that pulse oximeter readings—known to be less accurate for patients with greater skin pigmentation—used to determine supplemental oxygen levels in intensive care units resulted in non-white patients receiving less supplemental oxygen than white patients.[20]

Given the complexity of building AI tools, and the scale of data needed to successfully train a robust algorithm, it is extremely challenging to completely avoid the introduction of bias, and thus, rigorous evaluation of models for bias is essential. However, carefully designed AI tools may counter human biases or uncover previously unknown inequities in patient populations. It will be important to avoid both overreliance on AI tools that may be biased and under-reliance on AI tools that demonstrate less bias or that correct for known biases. Ultimately, appreciating and accounting for bias in AI model design, training, and use is essential to mitigating biases.

Explainability

Explainability refers to an end-user's ability to understand how an AI model works, specifically an ability to explain how an output was generated from inputs. There are many AI models that have high degrees of explainability (e.g., decision-tree models that predict the outcome of disease based on blood testing). However, newer AI models, especially foundational models, often have low degrees of explainability due to their sheer size and complexity, making it challenging for humans to understand or predict how the model will work.

Transparency

Transparency refers to the ability to access information about an AI model's training data (e.g., patient demographics) and model details (e.g., manufacturer, model) to help end-users determine whether the model will work as expected in their practice. It can also refer to the disclosure and documentation of the utilization of AI in health care decision-making. Ethical issues can emerge related to transparency –

for example, if incidental, non-significant findings are identified by an AI tool and presented to a patient. Ensuring that users have access to specific attributes about an AI model or tool—for example, evidence of clinical validation, steps taken to mitigate bias, descriptions of intended use and risks, among others—and sufficient training about how tools are developed and monitored is critical to increased transparency. Tracking when, where, and how AI is integrated into clinical settings is increasingly complex but necessary to ensure that patients are aware of the tools being used to help inform healthcare decision-making and where physicians are relying on outputs and recommendations from AI systems.

"Hallucinations"/Confabulation

AI hallucinations, or confabulations, refer to when a generative artificial intelligence algorithm creates outputs that are either nonsensical or appear credible but are factually inaccurate. For example, an AI tool could be asked to summarize a patient's medical history and might present inaccurate past diagnoses and/or current symptoms, or predict an outcome that is logically flawed based on existing data. On the one hand, as AI algorithms become increasingly complex, understanding when and how hallucinations happen becomes increasingly challenging. On the other hand, identifying and reducing hallucination events is a high priority for developers, and models are increasingly sophisticated in their logic processes. Interviewees and specialty society roundtable participants shared mixed perceptions on the implications of hallucinations: some physicians feel that AI tools must be resoundingly accurate and should not be used if there is any evidence of hallucinations; others believe that errors are an inherent part of human thought (and therefore also AI technologies), and so developers should strive to reduce AI errors, but physicians should not eliminate all algorithm use because of the possibility of hallucination. Understanding why AI models hallucinate, minimizing hallucinations in AI models, and mitigating the risk of harm are high priorities for AI model developers, physicians, and regulators.

Liability

Liability, resulting from inaccurate AI models or their misuse, is an area of great interest in the medical-legal field. However, given that AI is just beginning to be broadly adopted in health care, liability is largely unsettled. For example, if an AI tool recommends a certain prescription based on a patient's data, a physician prescribes that medication, and a patient has an adverse reaction, who bears the burden of responsibility—the physician, the company that owns the AI algorithm, or the individual or team who built and trained the AI algorithm? Emerging literature suggests that liability frameworks under product liability law, medical malpractice law, and ordinary negligence are likely to be applied to AI liability, though special consideration will need to be given to AI products.[21] Given the vast range of AI tools' applicability in health care—from administrative use cases to use cases with less impact on clinical decision-making (e.g., drafting a response to a patient question) to use cases that more directly support clinical decision-making—the question of liability is nonobvious and highly situational.

Coding and Payment

Payment for AI tools is nascent but growing. Until recently, there was no common terminology to describe health care services or procedures delivered via AI, and no standardized way to pay for those tools and services. In 2019, the CPT Editorial Panel established the first category Current Procedural Terminology (CPT®) code for an AI product, complemented in 2020 by Medicare's reimbursement of its first CPT code and New Technology Add-On Payment (NTAP) for AI devices.[22] CPT coding is distinct from payment but has important downstream impacts on valuation and payment. In 2021, the AMA's CPT Editorial Panel added a new appendix (Appendix S) to provide guidance for classifying various AI applications and determining the appropriate terminology to include in CPT code descriptors (Table 4). Appendix S divides AI applications

Table 4: AI taxonomy for medical services and procedures

Service Components	AI Category: Assistive	AI Category: Augmentative	AI Category: Autonomous
Primary objective	Detects clinically relevant data	Analyzes and/or quantifies data to yield clinically meaningful output	Interprets data and independently generates clinically meaningful conclusions
Provides independent diagnosis and/or management decision	No	No	Yes
Analyzes data	No	Yes	Yes
Requires physician or other QHP interpretation and report	Yes	Yes	No
Examples in CPT code set	Algorithmic electrocardiogram risk-based assessment for cardiac dysfunction (0764T, 0765T)	Noninvasive estimate of coronary fractional flow reserve (FFR) (75580)	Retinal imaging (92229)

into one of three categories—assistive, augmentative and autonomous—based on "the clinical procedure or service provided to the patient and the work performed by the machine on behalf of the physician."[23] Terminology that differentiates between the work of the physician and the work of the machine will help facilitate appropriate valuation and payment of AI. Developing common terminology for categorizing AI tools and services remains critical for the future utilization of AI tools across the industry. Over the next few years, establishing adequate payment for AI-based technologies will be essential in ensuring that AI-based tools are widely available, and not available only to health systems and practices that can afford to purchase them.

Privacy and security

Data privacy and security are of paramount importance. To function properly, AI development and training require access to large health data sets. The Health Insurance Portability and Accountability Act (HIPAA) and safe harbor laws protect personal health information (PHI) and other personal information, but were drafted before AI, especially generative artificial intelligence, had come into everyday practice. Today, few, if any, technical controls are available to help end users specify how data entered into AI systems are used, reused, or how data are used to train AI systems. In addition, AI with access to user data might inadvertently reveal personal health information about a patient and/or be able to re-identify de-identified information.

Given that AI generates outputs based on the learned logic and patterns of datasets, malicious disruption to training datasets has the potential to corrupt models and produce inaccurate outputs. Additionally, AI-operated ransomware and AI-operated malware can be used to gain access to user data and/or health information technology (health IT) systems. Thus, how data are stored, where and for how long are critical privacy and security considerations for AI and more broadly.

Regulation and oversight

The regulatory landscape for AI, which was previously limited at both the federal and state levels, is seeing a significant uptick in activity. While there is no comprehensive federal legislation dedicated to AI, the White House published an Executive Order in 2023 to establish safe, secure, and trustworthy AI; Congress is conducting hearings; and several federal agencies,[24] with the FDA[25] at the forefront of development, are increasingly issuing guidance. Most recently, the Office of the National Coordinator for Health IT developed new policies that require health IT developers to make certain information about AI used in EHRs available to clinicians.[26] Similarly, states do not currently have robust policy frameworks for the regulation of AI, although legislative activity is expected to accelerate significantly in the coming years.

While government entities play a critical oversight role, health care institutions, practices and professional societies also monitor AI-enabled systems and technologies, and they determine which tools are implemented and manage and maintain those tools over time. Notably, clinical experts are best positioned to determine whether AI applications are high quality, and thus they are a critical voice in determining whether AI tools are clinically valid and appropriate for use, which will require these experts to have a foundational knowledge about the development and deployment of AI tools. Post-market surveillance of AI performance is also a concern, as tool performance in practice may differ from a training environment; health care organizations will need to monitor tool performance for accuracy, equitable use and patient outcomes.

Both timing and complexity are difficult regulatory challenges. Regarding the former, AI technologies and use cases are developing faster than regulators can keep pace with. Regarding the latter, the topics that require regulation are technically complex and include several of the risks listed in this section: data privacy, liability, patient consent, model transparency, quality control and standardization, fairness and bias, intellectual property considerations, data ownership, and algorithm quality control, among others.

Overall, significant regulatory gaps exist. Effective regulation and oversight of AI that balances its promises and risks will require meaningful collaboration among clinicians, policymakers and government officials, experts in artificial intelligence, and a wide range of academic, industry, and non-profit stakeholders. In the meantime, physicians should seek foundational training in the development and deployment of AI tools and voice concerns they identify regarding tools used in their clinical environments.

AMA Commitment

The AMA recognizes these challenges and is committed to supporting physicians, health care stakeholders and policymakers navigate each. The "AMA AI Commitments" section below details the AMA's activities in support of these challenges, including developing AI principles, supporting policy development, providing educational materials, and ensuring physician voices lead the discussion on development, access, quality, and ethics.

Considerations for using AI in your practice

As AI products and tools become increasingly available, physicians and health systems may begin evaluating if and how to integrate AI solutions into their practice. The AMA's interviews and physician survey underscored physicians' interest in ensuring that adopted AI tools have strong data privacy protections,[27] are safe and effective,[28] integrate well with existing technology solutions,[29] and protect physicians from liability made by algorithmic error.[30,31] Notably, physicians also expressed interest in being involved in the adoption of AI tools, with 86% of surveyed physicians indicating they would like to be either responsible or consulted in the process.[32]

Below are a few key questions to consider[33] at each stage of identifying and implementing an AI tool into a practice setting. Importantly, the identification and implementation of AI tools requires collaboration across organizations – physicians will not be conducting the following independently. Technology teams, clinical informaticists, administrative leaders, and physicians will need to work together to ensure AI tools are incorporated and used effectively:

Phase I Identify the challenge and use cases	Phase II Evaluate AI tools	Phase III Implement AI tools	Phase IV Manage AI tools
Problem identification: • What problem are you trying to solve with AI in your practice (e.g., excessive work outside of work, opportunity to augment efficiencies in workflow)? • How would you define success in using an AI tool to address this problem? **Use case identification:** • Do AI tools exist that address the problem? • Are available tools point solutions and/or solutions with broad applicability? • Who needs to be involved in evaluating/selecting a solution? **Awareness of risks:** • What are the AI risks (see list on page 15) related to the challenges facing your practice? • Which problems can AI solve without introducing unacceptable levels of risk? **Liability:** • What are the risks and liability you incur by using AI in your medical practice?	**Data use and transparency:** • What data was the AI tool trained on (e.g., how expansive was the data set, is it representative of the patient population?)? • What data protections are guaranteed by the tool? **Performance evaluation and validation data:** • What information and evidence are provided regarding the performance of the tool? • What data are provided to validate performance of the tool? **Infrastructure requirements:** • What technology infrastructure is necessary for the tool to operate? • Is the tool stand-alone, or does the tool integrate with existing technology systems (e.g., EHR)? **Approval status:** • What is the approval status of the tool (i.e., has the tool been FDA cleared or approved, validated by some other third party, or a peer-reviewed study)? **Financial implications:** • What are the financial implications of integrating the tool (e.g., cost of tool, increased revenue, decreased cost of care)?	**Training:** • How will end-users be trained on using the AI tool? • How does training instill confidence in end-users by ensuring the ethical use of the AI tool? **Dissemination:** • How will the AI tool be disseminated (e.g., change management)? **Workflow:** • How will the AI tool be integrated into clinical and administrative workflows in the most seamless way? • How will users report issues/errors? How will leaders identify systemic issues? **Technology support:** • What technology foundation is necessary for the AI tool to operate at peak capacity? **Bias risk:** • How can product owners ensure the consistent examination of AI tools to identify and rectify biases, preventing unintended consequences that may disproportionately affect marginalized groups?	**Maintenance:** • How will the tool be maintained over time (e.g., technical updates, data corrections)? • How will updates or changes to the tool be disseminated to end-users? **Monitoring:** • How will the tool be monitored for success? • How will the clinical environment be monitored for impact of AI tool (e.g., clinical outcomes, administrative efficiencies)? • How will the clinical environment be monitored for digital or data drift (e.g., different patient demographics) that may impact accuracy of AI tool? **Financial implications:** • What is the ROI or ROH of the tool? **Bias implications:** • What measures can be implemented to continuously identify biases and ensure fair and equitable access to the AI tool for all user groups? **Training:** • How will end-users be re-trained on using the AI tool?

Health Equity:
Leaders should work to ensure equity across all stages: soliciting input from marginalized communities, evaluating tools based on whether training data sets incorporate a diversity of populations, ensuring access to tools for all provider types and patient populations, and monitoring tools to validate that they don't disproportionately impact certain patients.

Case studies

Physicians vary in what they believe are the most helpful resources for evaluating AI tools—some indicate clinical evidence, others point to continuing medical education (CME) courses or implementation guides—but there is a general perspective that peer-review literature and clinical trials are important references when deciding whether to use an AI tool.[34] These cases illustrate current and effective uses of AI.

CASE STUDY 1: Speech-to-text documentation

Leveraging AI to support the documentation of medical charts and/or visit notes is considered one of the most highly relevant use cases to physicians and already approximately 13% of surveyed physicians currently use AI to do so.[35,36]

The American Academy of Family Physicians (AAFP) conducted a study[37] to determine whether the use of an AI assistant reduced documentation time for physicians. An "AI assistant" is a product that uses voice recognition, natural language processing, and other AI technologies to listen to a patient-physician encounter and not only generate a transcript of the encounter (similar to commonly used dictation devices), but also draft an encounter summary, enter relevant information directly into EMR systems, and/or order labs upon physician request.

Study design

The AAFP recruited physicians to use an AI assistant for medical notes. Over one month, 132 family medicine physicians and PCPs across 47 clinics and 18 states participated.

Results

The majority of physicians were interested in continuing to use the AI assistant after the study concluded.

- Sixty percent of physicians ("adopted" physicians) continued to use (and started paying for) the AI assistant after the study concluded
- Forty percent of physicians ("not adopted" physicians) chose not to continue use of the tool after the study concluded. Three primary factors contributed to the group's decision not to adopt the new technology: (1) many reported no or little initial documentation burden; (2) their EHR was not integrated with the AI solution[38]; (3) they were too challenged by current workloads to adopt a new solution.

There was a 50%–72% reduction in median documentation time.

- Seventy-two percent reduction in median documentation time per note for adopted physicians
- Fifty percent reduction in median documentation time per note for not adopted physicians

Over 3 hours per week were saved.

- Adopted physicians saved 3.3 hours per week

Physicians indicated improved satisfaction and reduced feelings of burnout.

- Improved satisfaction with workload and overall practice
- Decreased feelings of burnout

CASE STUDY 2: Using Artificial Intelligence-based diagnostics for diabetic retinopathy screening in primary care.

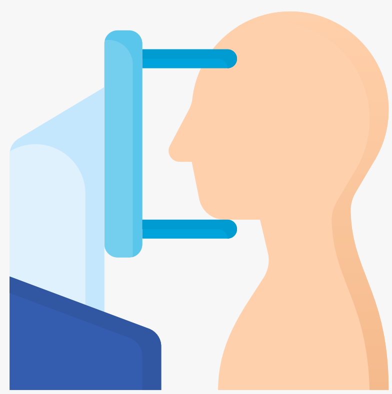
Autonomous artificial intelligence systems in health care are those that interpret data and independently generate clinically meaningful conclusions.

In 2018, the FDA approved its first autonomous artificial intelligence system for the detection of diabetic retinopathy (DR), providing physicians with the option to test for DR without needing a specialist to interpret images and make a referral to an ophthalmologist, if appropriate.

The FDA's approval was based on a study[39] that enrolled 900 diabetic patients with no known history of DR or diabetic macular edema (collectively mtmDR), across 10 primary care sites. Each participant's ocular image was reviewed by both an image specialist and an autonomous artificial intelligence tool.

The imaging specialists identified 621 patients who were negative for mtmDR and 198 who were positive for mtmDR. Of the 621 specialist-identified negative patients, the artificial intelligence tool categorized 556 as negative for mtmDR. Of the 198 specialist-identified positive patients, the artificial intelligence tool categorized 173 as positive for mtmDR.

Pre-specified primary endpoint goals were a sensitivity of greater than 85% and a specificity of greater than 82.5%. The artificial intelligence system surpassed both, with a diagnostic accuracy sensitivity of 87.2% and a specificity of 90.7%.



Ultimately, the study demonstrated the potential for an artificial intelligence system to support PCPs in the evaluation of DR. Given the high risk of blindness due to DR and the low rates of patient adherence to recommended ocular screenings, there is an opportunity for artificial intelligence to augment opportunities for patients to obtain accurate eye screenings and for physicians to potentially intervene earlier in the disease progression.

Autonomous retinal imaging is a billable service and is included in the AMA's Taxonomy for Medical Services and Procedures Appendix S (see Table 4 on page 17) under the category of "autonomous medical services." Autonomous medical services and procedures are classified as those that (1) provide independent diagnosis and/or management decisions, (2) analyze data, (3) do not require physician or other qualified health professional interpretation and report.

AMA AI commitments

The AMA is committed to ensuring that the evolution of AI in medicine benefits patients, physicians and the health care community. As the use of AI in health care evolves, the AMA will:

Develop “AI principles” for the use of AI in health care

Given the evolving nature of AI tools and capabilities, the AMA recognizes the importance of routinely revising and expanding principles to reflect the changing needs of patients and physicians and the increased capabilities of AI tools and services. The AMA’s policies on AI, first adopted in 2018 and refined in a 2019 Board Report and CME Report, recognize the technology’s potential for enhancing patient and physician decision-making and improving health outcomes. In November 2023, the AMA released new principles that consider AI oversight, AI transparency, generative AI, AI data privacy, AI cybersecurity, and the use of AI and automated decision-making systems by payers and health plans. As the landscape evolves and more is understood about appropriate forms of health care AI, the AMA will continue to refine principles, including those regarding AI governance and oversight.

Support the development of state and federal policies that ensure appropriate oversight and continued innovation in AI

The AMA is actively engaged in federal and state advocacy efforts to advance the safe, effective, transparent, ethical and equitable use of AI tools and services. The AMA will continue this work, advocating for policies that promote equitable access to AI tools and reduce the risk of bias in AI models and use. Furthermore, the AMA will advocate for the protection of physicians and patients from false or misleading AI-generated medical advice and content. The AMA will actively engage with Congress and the Administration as they promulgate new laws and regulations, and will continue to partner with state and medical societies to advance AI policies at the state and federal levels.

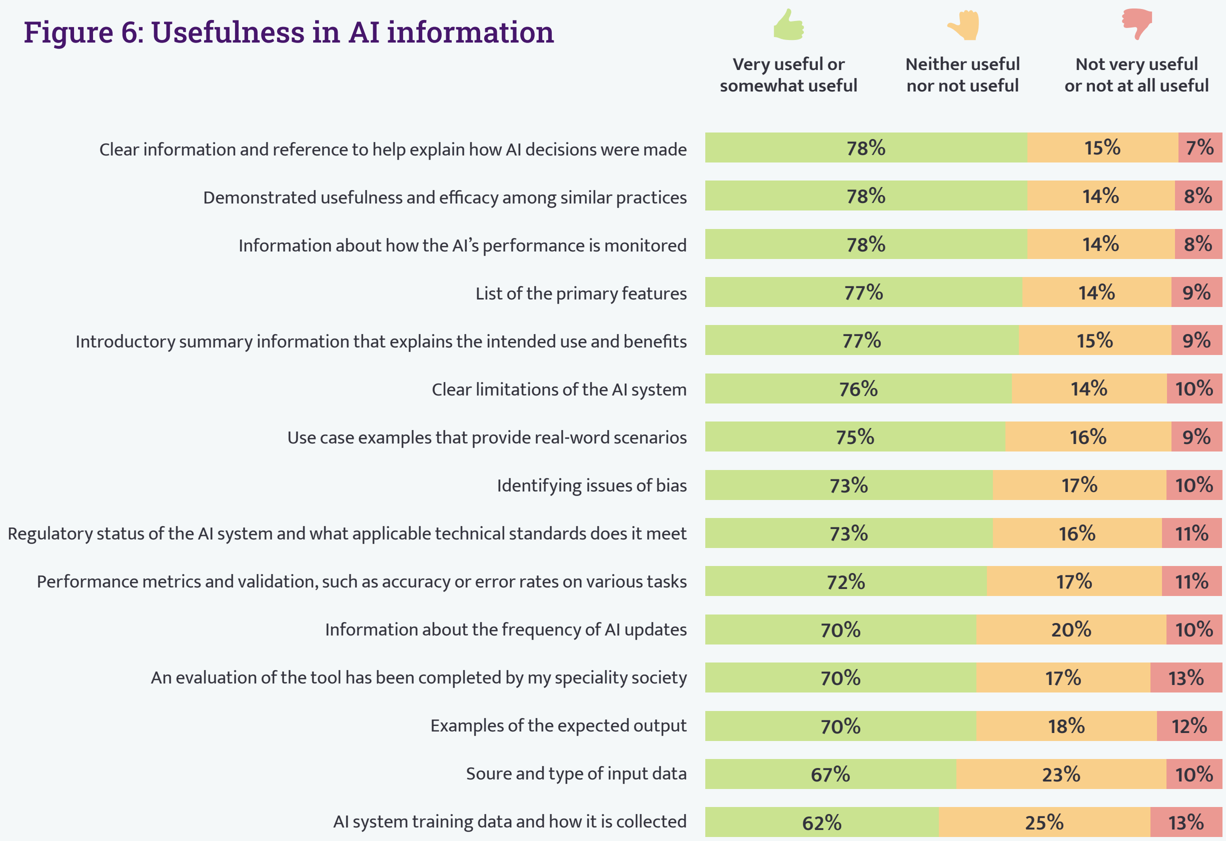
Collaborate with health and technology leaders to research AI’s applications and ensure that physicians have a leading voice in shaping AI’s role in medicine

To generate this report, the AMA conducted interviews with experts in AI and clinical technology and convened a specialty society roundtable with the goal of better understanding the risks, benefits and unforeseen consequences of AI in health care. The AMA will continue convening specialty societies and other clinical expert stakeholders on the topic of AI in health care. Additionally, the AMA will continue to center the physician’s voice in the development of policies and principles and creation of research and/or resources. Given the rapidly evolving generative AI environment, this will be an area of focus for the AMA over the next year and beyond.

Prepare and inform physicians by providing high-value insights and actionable resources[40]

The AMA's recent 2023 AI Physician Survey indicated that more than 75% of respondents would find it very or somewhat useful to have clear information that explains an AI tools' efficacy, features, risks or limitations, real-world use case examples, and performance monitoring standards (Figure 6).[41] The AMA is committed to supporting this interest from physicians and ensuring physicians have sufficient information and foundational training to make informed decisions, inform the development of these tools, and use AI effectively.

Figure 6: Usefulness in AI information



The AMA crafted a framework to promote the development and use of responsible, evidence-based, unbiased and equitable health care AI. This framework has also been leveraged to create a companion resource that considers educational applications of AI and addresses the use of AI to facilitate the process of training health professionals.

Furthermore, as a member of the Health AI Partnership—a collaboration among 14 health care organizations and ecosystem partners—the AMA is encouraging the collaborative development and dissemination of AI best practices. The AMA will continue to work with this partnership and others to develop resources, including a case-based AI ethics training program that will delve into real-world, contemporary challenges that physicians and health care delivery organizations face when using AI.

Looking ahead, the AMA is committed to expanding these educational resources, developing new toolkits to support the implementation of clinical and administrative AI tools, and exploring new venues for delivering high-impact and actionable resources on the topics most relevant to physicians.

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Interviewee	Title	Organization
Ami Bhatt, MD, FACC	Chief Innovation Officer	American College of Cardiology
Michael Abramoff, MD, PhD	Founder and Executive Chairman	Digital Diagnostics
Mark Sendak, MD, MPP	Population Health & Data Science Lead	Duke Institute for Health Innovation
Daphne Koller, PhD, MSc	Founder and CEO	insitro
John Halamka, MD, MS	President	Mayo Clinic Platform
Tom Lawry	Former National Director for Artificial Intelligence	Microsoft
Peter Lee, PhD	Corporate Vice President, Research and Incubations	Microsoft
Abel Kho, MD	Professor of Medicine; Founding Director	Northwestern University; Institute for Augmented Intelligence in Medicine
Srinivas Sridhara, PhD, MHS	Chief Data and Analytics Officer	Penn Medicine
Ed Lee, MD, MPH	Former Executive Vice President of IT and Chief Information Officer	The Permanente Federation, LLC
Harlan Krumholz, MD, SM	Director	Yale New Haven Hospital Center for Outcomes Research and Evaluation
Atul Butte, MD, PhD	Director, Bakar Computational Health Sciences Institute	University of California, San Francisco

Acknowledgments (cont.)

Specialty society representative	Title	Specialty society
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Peter Campbell, MD, PhD	Chair, Committee on AI	American Academy of Ophthalmology
Scott Haber	Director, Public Health Advocacy	American Academy of Ophthalmology
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Nathaniel DeNicola, MD, MSHP	Chair of Telehealth	American College of Obstetricians and Gynecologists
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Laura Coombs	VP, Data Science and Informatics	American College of Radiology
Matthew Hanna, MD, FCAP	Vice Chair, AI Committee	College of American Pathologists
Christopher Carr	Director of Informatics	Radiological Society of North America
Adam Flanders, MD	RSNA Board of Directors, Liaison for Information Technology	Radiological Society of North America

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[25] While the FDA regulates AI-enabled medical devices, many types of AI-enabled technologies currently fall outside the scope of FDA oversight, or FDA is exercising enforcement discretion, including AI that may have clinical applications, such as certain clinical decision support functions.

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[27] Eighty-seven percent of physicians surveyed indicated "Data privacy is assured by my own practice/hospital and EHR vendor" as very or somewhat important.

[28] Eighty-four percent of physicians surveyed indicated "Its safety and efficacy is validated by a trusted entity" as very or somewhat important; 82% indicated "Is proven to be as good or superior to traditional care" as very or somewhat important.

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[29] Eighty-four percent of physicians surveyed indicated "Is supported and well-integrated with my EHR" as very or somewhat important; 82% indicated "Is well integrated into practice workflows" as very or somewhat important.

[30] Eighty-seven percent of physicians surveyed indicated "I am not held liable for errors of AI models" as very or somewhat important; 86% indicated "Is covered by my standard malpractice insurance" as very or somewhat important.

[31] AMA's 2023 Augmented Intelligence Research: Physician Sentiment Report

[32] AMA's 2023 Augmented Intelligence Research: Physician Sentiment Report

[33] Phrases and key questions adapted from Health AI Partnership resource materials.

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