

**LEADERS: Skilling/Reskilling Framework for the Future AI Workforce -  
Demonstrated by a Healthcare Case Study**

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## Executive Summary

In the current era of unprecedented technological advancement, where Artificial Intelligence (AI) is reshaping industries and workforce dynamics,<sup>1-2</sup> this paper introduces a strategic roadmap for academia, industry, and individuals to harness the transformative power of AI. The evolution of AI from task automation,<sup>3-6</sup> exemplified by systems like ChatGPT, DALL-E 2, and Google's PaLM, underscores the need for a skilled workforce adept at navigating the intricacies of AI applications.<sup>1,7-8</sup>

Moreover, there is an even larger growing need for skills outside of computer science. Specifically, industries are seeking people with AI literacy, with the knowledge and skills to understand, use, and interact with AI responsibly and effectively within various industries. With the scale and speed at which AI is transforming all aspects of industry and academia, an AI skills gap is emerging which can significantly impact industry progress, AI development, and the future workforce availability.

To address the escalating demand for AI expertise and skills gap, we have developed the LEADERS framework which outlines the necessary skills needed to train and develop the future industry leaders and developers. The LEADERS Framework is a model comprising seven key pillars essential to AI training: Literacy, Enablement, Application, Development, Ethics & Governance, Research & Refinement, and Society. Each pillar is designed to cater to all professional roles pertaining to AI and AI development within the scope of academia and/or industry, thus creating customized pathways to develop and train individuals to develop AI proficiency. The framework is illustrated through three role categories aligned with technological evolution. Traditional technology roles are supported by Literacy and

Refinement, which enables individuals to develop their AI knowledge base and refine their AI use and development skills. AI technology roles, such as Machine Learning Engineers and AI Data Scientists, require AI Literacy, and an understanding of AI Application and Development, to ensure

**Figure 1**  
LEADERS Framework: Driving Change Across Three Lenses



practical Implementation of AI tools and Innovation. Leadership roles in AI, such as AI Translators and Governance Leads, focus on AI strategy and evaluation of AI systems, require a strong foundation in AI literacy to ensure effective and responsible AI across the organization.

The LEADERS Framework assists professionals across various roles including **Frontline workers, Managers and Business Leaders** in navigating the ever-changing AI landscape as seen in Figure 1. Through the LEADERS framework, individuals can obtain the foundational training needed to understand and master the required AI skills to drive innovation. By adopting the LEADERS framework, organizations can foster a culture of continuous learning and innovation, while positioning themselves at the forefront of the AI revolution.

To illustrate the practicality of our LEADERS framework in healthcare, we've developed a case study illustrating healthcare patient interaction. This real-world example showcases how the LEADERS framework can be utilized to address healthcare challenges, enhance patient diagnostics, and improve patient outcomes. However, caution is paramount, such as ethical considerations, data privacy, and disparities/bias must be proactively addressed.<sup>9-10</sup> Success in AI adoption relies on transparent governance, following ethical AI frameworks<sup>11-12</sup>, and a commitment to upskilling the workforce.<sup>13-16</sup>

In conclusion, the LEADERS framework is a tool to assist individuals in obtaining AI mastery. Furthermore, we are calling for a call to action for leaders in education and industry to assist in the reskilling of the current workforce and skilling of the future generations in AI. Embracing AI and investing in AI proficiency development will unlock new opportunities, drive innovation, and secure a competitive edge in the rapidly evolving digital landscape.

## Foreword

As society stands on the threshold of an innovative era, marked by the prolific advancements in AI, there emerges a profound mandate for academia, industry and individuals to not only comprehend this intricate technology, but harness it proficiently. To address this need, the present paper details an inclusive AI skills training framework named LEADERS, which is uniquely designed to resonate with industry needs and academia alike.

The LEADERS framework acts as a comprehensive roadmap for navigating through this new AI landscape for all individuals across various roles, including frontline workers, managers and business leaders. Furthermore, the framework enables users to decode and strategically deploy AI within their distinctive professional and academic environments. The LEADERS framework allows for the facilitation and training of individuals to ensure that individuals understand how to implement real-world applications and breakthroughs with the help of AI. Industry is in enormous need for skilled employees who are proficient in AI, hence the need for substantial investment in AI skill development.

To illustrate its effectiveness and applicability, the LEADERS framework is viewed through the lens of a healthcare sector-specific case study, encapsulating its potential to revolutionize diagnostics and patient care. The case study embodies the universal applicability of the framework, demonstrating its adaptability to fit a distinct industry, thereby enhancing its practical utility.

Nevertheless, while acknowledging the potential of AI, with vigilance towards its challenges, such as ethical considerations and data privacy, society must maintain a commitment to mitigate the inherent disparities or biases associated with widespread AI use. Ultimately, the LEADERS framework presents itself not merely as a call for engagement with AI but as a pathway towards a future where comprehensive AI literacy becomes a fundamental tenet, arming society and businesses with the skills to navigate an increasingly digitized future with confidence.

## Research Methodology

In crafting the LEADERS framework, we closely examined United Nations Educational, Scientific and Cultural Organization (UNESCO)’s comprehensive analysis on AI curriculum development, which served as a foundational reference.<sup>17-18</sup> (Table 1) The insights

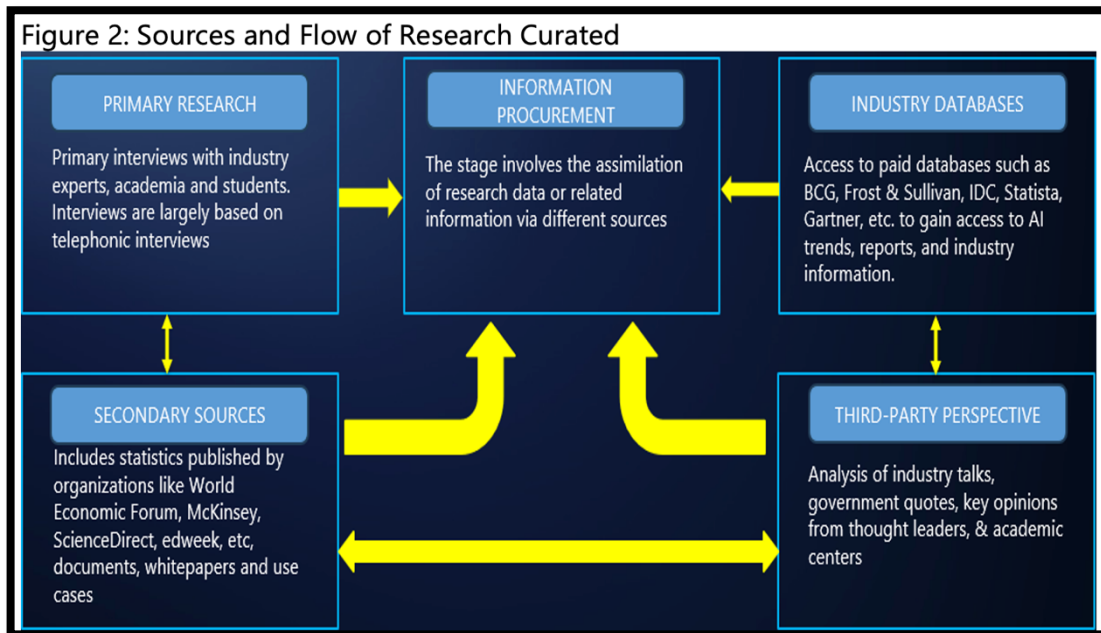
Table 1: LEADERS Framework design based on UNESCO

UNESCO AI Curriculum & LEADERS Framework Alignments		
Component	UNESCO AI Curriculum Areas	Connection to LEADERS Framework
Foundation Establishment	AI Foundations: Algorithms, Computational Thinking	Grounding in fundamental AI principles aligns with foundational knowledge in the "Foundations of AI" pillar.
Understanding, using and developing AI	AI technologies are often human-facing applications. Developing AI technologies deals with the creation of new AI applications that may address a social challenge or provide a new type of service	AI and data literacy insights guide the integration of maths and science & and other useful aspects in the "Enabling AI Solutions" and "Strategic AI Applications" pillars.
AI Techniques	<ul style="list-style-type: none"> <li>Understands how neural networks work and their parts (feed forward, evaluation of a prediction for accuracy, back propagation)</li> <li>Explains types of AI techniques and how they work (supervised, unsupervised, reinforcement, ML/DL)</li> </ul>	Utilizing contextual problem-solving methods to incorporate AI in various subjects, relevant to the "AI Development" pillar.
<ul style="list-style-type: none"> <li>Ethical and Governance Framework</li> <li>Inclusivity and Accessibility</li> <li>Societal Engagement</li> </ul>	<ul style="list-style-type: none"> <li>Ethics and social impact : Ethical terms, definitions, and understanding biases</li> <li>Social Implications of AI: AI's advantages and disadvantages, AI in everyday life</li> </ul>	<ul style="list-style-type: none"> <li>Ethical considerations in AI curricula shape the "AI Ethics &amp; Governance" pillar.</li> <li>Societal engagement and understanding AI's broader impacts guide community practice and knowledge sharing in the "Society" pillar.</li> </ul>
Performance Measurement	Interprets the performance of a ML model (e.g. using a confusion matrix)	Evaluating AI learning outcomes to inform ongoing optimization and bias reduction in the "Research, Oversight & Value Measurement" pillar.

garnered from these documents helped shape a nuanced methodology that underpins the core pillars of our LEADERS framework. Below is a structured table that aligns the insights from the UNESCO report with the LEADERS framework pillars, starting from the first pillar to the seventh. UNESCO’s approach, which involved responses and curriculum documents from a significant number of countries, has provided a rich foundation for understanding the global landscape of AI education. This has been instrumental in shaping a curriculum framework that is both adaptable to various educational needs and aligned with international standards and best practices.

The research methodology employed for analyzing the AI talent gap adopts a comprehensive approach that integrates both secondary and primary research strategies. The secondary research component involves meticulous data compilation from a diverse array of trusted sources, including hundreds of independent studies, official government and regulatory documents, scientific periodicals, industry magazines, and access-controlled databases. This phase aims to provide a comprehensive understanding of the current landscape and future trends in AI talent development.

In the primary research component, the key objectives are to quantify the current AI talent gap through extensive data analysis and develop an actionable blueprint for addressing the AI skills shortage based on expert insights. The data procurement process, as illustrated in Figure 2, involves extracting insights from reports by esteemed entities such as the World Economic Forum, Gartner, McKinsey, National Institute of Standards and Technology, academic journals, media publications, and education websites.<sup>19-26</sup>



The research commences with an analysis of how AI is transforming industries and workplaces, providing context on the emerging roles and skills required for AI adoption across sectors. The demand for these skills and the talent supply are quantified through secondary research on talent gaps globally and by industry. To capture qualitative perspectives, in-depth interviews were conducted with thought leaders in academia and industry. These discussions assess real-world challenges and potential solutions for developing AI competencies.

The research journey encompasses assessing AI's business impacts, sizing the talent gap, and gathering on-the-ground insights into strategies for upskilling and education. This multifaceted approach allows for the creation of an evidence-based framework for creating a robust AI talent pipeline. The methodology leverages a combination of primary and secondary research, drawing on a diverse range of data sources to offer a multifaceted perspective on the impact of AI on the labor landscape.

In-depth interviews with healthcare professionals, including clinicians, industry experts and university professors, as well as other subject matter experts, provide valuable insights

into the ramifications of AI on the workforce. Independent market research and analysis, supplemented with insights from leading consulting firms like McKinsey, Gartner, and Forrester, deepen the understanding of AI's current applications in the workplace and its potential trajectory in the coming years.<sup>27-35</sup>

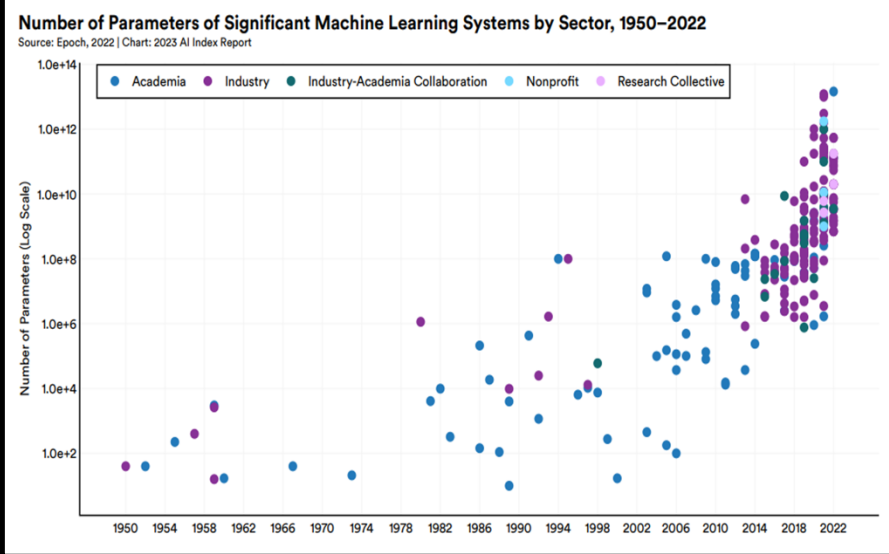
To further corroborate the findings, online platforms such as LinkedIn are utilized to gather evidence supporting the growing demand for AI skills and AI Literacy. This exploration underscores the urgent need for reskilling initiatives, an immediate concern anticipated to grow exponentially in the future if action isn't taken to mitigate the risk. The approach ensures a robust and forward-looking analysis that reflects the dynamic and rapidly evolving AI landscape in the professional and academic environments.

## Understanding the AI Skills Gap

The evolution of the artificial intelligence (AI) industry, marked by collaboration between academia, technological advances, and industry applications, has uncovered a significant gap in AI skills training. Originating as a vision for a collaborative partnership between humans and machines, the trajectory of AI development traces back to Alan Turing's predictions in 1950.<sup>36</sup> Turing suggested that the best strategy for achieving AI is to produce a machine that is capable of learning and improving itself. We can now see this prediction coming to life in the form of machine learning and deep learning algorithms. However, this AI evolution has advanced at a much faster pace, which resulted in educational institutions falling behind in the training and development of the next generation of AI professionals and developers. Thus, society has been limited in its ability

to fully harness AI's potential. AI has transitioned through distinct phases, from symbolic AI in the 1950s-1980s to the machine learning renaissance of the 1990s-2000s and the era of big data and deep learning in the 2010s (see Figure 3).<sup>37-39</sup> In the present landscape, AI skills and AI literacy has become integral to various industries,<sup>1,40</sup> presenting opportunities in automation, data analytics, healthcare, and more. Despite these opportunities, a

Figure 3: Evolution of Machine Learning Systems





substantial skills gap exists across academia and the workforce.<sup>7,41-42</sup>

This gap is particularly pronounced in education, where barriers to entry hinder the seamless integration of AI into university programs. **The shortage of qualified AI professors and AI institutes in the United States contributes to the challenge, as top researchers are likely drawn into the private sector due to higher salaries and benefits.**<sup>43-44</sup> Students face barriers such as

"Things are moving too rapidly in the world of AI. To remain relevant, we have to teach our students how to learn and fast."

Vishal Mishra PhD, Professor of Computer Science,  
Columbia University

prerequisite coursework, complex subject matter, and uncertainty about the skills sought by employers in the evolving AI job market.<sup>45-46</sup> As the AI job market evolves, students struggle to find practical training opportunities, in conjunction with limited availability of AI apprenticeships and internships.

AI skills acquired through online platforms or trade courses adds further complexity to the educational landscape.<sup>21,47</sup> Traditionally, higher education institutions like universities or colleges have been the primary providers of specialized knowledge, like AI. **However, the rise of online platforms and trade courses has disrupted this model, now allowing anyone with internet access to gain expertise in complex areas such as AI. Online platforms like Coursera, edX, Udacity, and LinkedIn Learning deliver comprehensive courses on artificial intelligence, machine learning, data science, and other relevant fields. Many of these courses are designed by professors from renowned universities or professionals in leading tech companies.** The benefits afforded through these courses include, that these courses are often self-paced, flexible, and cost less than traditional degrees, making these educational courses more accessible to the general population. The value of these courses is recognized by many employers who want to hire people with practical and up-to-date skills. This adds complexity to the educational landscape as it raises questions around the formality of education, the validation and recognition of online credentials, and the perceived value between online, trade courses, and formal university education.

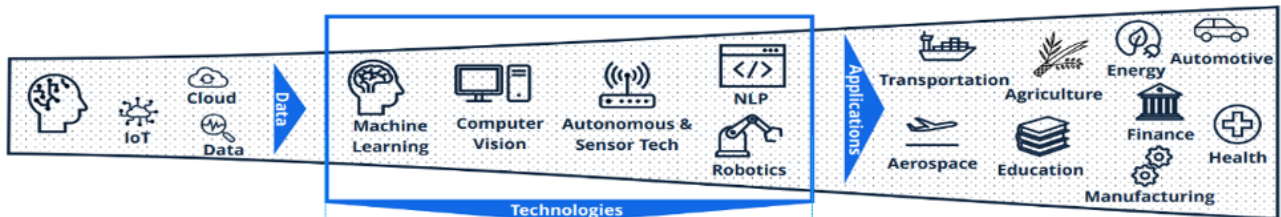
The rapid advancement of AI has given rise to two critical spheres of skill expertise: AI Technology and AI Strategy & Governance, as illustrated in Figure 4.<sup>48</sup> Each sector plays a pivotal role in the life cycle of AI systems, ensuring not only the technological robustness but also the strategic and ethical integrity of AI implementations, AI technology roles & AI strategy & governance roles. AI technology roles encompass the hands-on development and operationalization of AI systems. **This includes AI Model and Prompt Engineers, who are responsible for the technical development and refinement of AI algorithms and infrastructure.** AI ML Engineers play a pivotal role in designing, coding,

and integrating AI models, ensuring they perform optimally within various systems. AI Product Owners & Interface and Interaction Designers are crucial for creating user-centric interfaces, allowing for seamless human-AI interaction. AI Data Scientists delve into data analysis and machine learning to inform model training, while AI Solution Architects design the structural foundation of AI systems for scalability and robust performance. AI User Experience Researchers bring insights into user behavior to refine the AI experience.

**Figure 4: AI Advancements Leading to Changing Roles in the Workforce**

As "AI" continues to advance, it unveils a diverse range of roles, spanning from data scientists to business practitioners.

The expansion of AI from infrastructure to industry



Traditional Technology	AI Technology	AI Strategy & Governance
<ul style="list-style-type: none"> <li>Infrastructure, Operations and Cloud</li> <li>Application Development</li> <li>Cybersecurity</li> <li>Data Analytics</li> </ul>	<ul style="list-style-type: none"> <li>Machine Learning Engineers</li> <li>AI Data Scientists</li> <li>Prompt Engineers</li> </ul>	<ul style="list-style-type: none"> <li>AI Translators</li> <li>AI Product Owners</li> <li>AI Governance Leads</li> <li>AI Leadership</li> </ul>



Source - McKinsey Global Institute, LinkedIn  
Demography- US  
Data - 2023  
Industry - All

On the strategy and governance side, roles like AI Translators, bridge the technical and business worlds, ensuring AI capabilities are in lockstep with business strategies and objectives. AI translators are thought to represent the largest upcoming skill gap. AI Governance Leads take charge of testing and evaluating AI outputs, focusing on ethical use, safety, and compliance with regulatory standards. AI Ethics and Compliance Officers ensure AI applications adhere to ethical practices and respect user privacy and rights. AI Leaders steers the organization's AI vision, governing the ethical, strategic, and operational dimensions of AI initiatives. Finally, AI Business Analysts analyze market trends and business needs to ensure AI strategies create value and are aligned with the company's long-term goals.

In essence, the bifurcation between AI technology and AI strategy & governance roles represents the hands-on creation and practical application of AI tools versus the oversight, ethical guidance, and strategic alignment of AI within an organization. Both streams work in tandem to harness the transformative power of AI while ensuring responsible and value-driven integration into the business ecosystem.

To bridge the AI skills gap, a collaborative effort between US universities and industry leaders is crucial.<sup>49</sup> Our recommendations include investing in AI professors and institutes, fostering industry-academia partnerships with leaders like Microsoft, IBM, and Google, and streamlining prerequisite coursework for broader access.<sup>50-51</sup> The establishment of a governing body connecting emerging students with thought leaders can guide AI education, ensuring it remains relevant and adaptive.<sup>52-53</sup> Providing hands-on experience opportunities, such as internships and apprenticeships, is crucial for students to practically apply AI knowledge. Industry plays a vital role by offering apprenticeships and internships, collaborating on AI curricula with universities, and providing financial support to students, particularly those from lower socio-economic backgrounds.<sup>54-55</sup>

"Educators need to embrace AI, so there's no surprise of its positive and negative impacts."

Atul Prakash PhD,  
Professor, Engineering and Computer Science,  
University of Michigan

## The AI Skills Gap: Supply and Demand Dynamics

The current state of AI skills in the workforce reveals a stark imbalance between supply and demand, influenced by trends in education, shifts in the job market, and the rapid evolution of AI technologies.<sup>7-8</sup>

<sup>8</sup> Notably, there's a concerning stagnation in the number of Computer Science (CS) PhD graduates since 2010, coupled

with a decline in new AI PhDs entering academia.<sup>56</sup> On the demand side, a surge in AI hype and adoption is evident, with global AI investment reaching \$91 billion in 2022. Approximately 50% of global entities are exploring AI, and 30% are actively deploying AI solutions.<sup>57-58</sup> The rapid evolution of AI models and tools intensifies this demand, reflected in the doubling of career opportunities posted on LinkedIn requiring AI skills since 2022.

Looking ahead to 2030, AI is expected to reshape 65% of job skills, emphasizing the urgent need for targeted education and training.<sup>21</sup> The segmentation of roles in the AI ecosystem underscores diverse needs, with the talent market bottleneck shifting towards

AI expertise<sup>46,59</sup> as seen in Figure 5. Organizations face the challenge of finding skilled professionals who can develop and implement AI solutions while navigating ethical, legal, and societal landscapes impacted by AI (Figure 6).

This shift reflects the need for AI trained individuals possessing a diverse range of skills needed to fulfill industry needs in the newly developed AI ecosystem, which requires technical expertise, ethical governance, and strategic business insight at a minimum. Figure 7 summarizes the skills gap identified and as it relates holistically to the framework established.

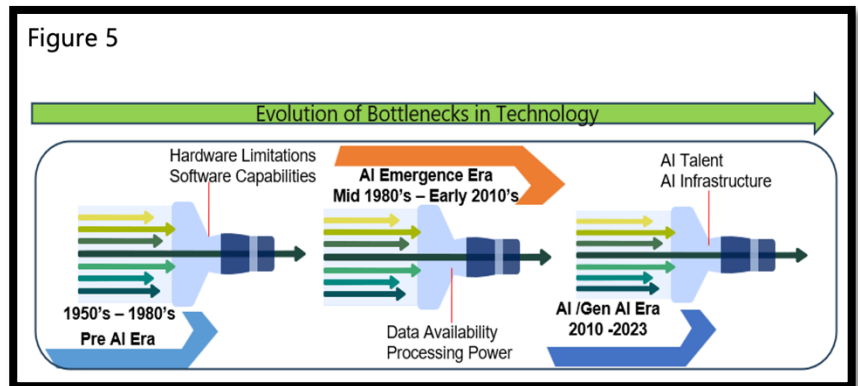


Figure 6: Challenges contributing to AI Talent Gap

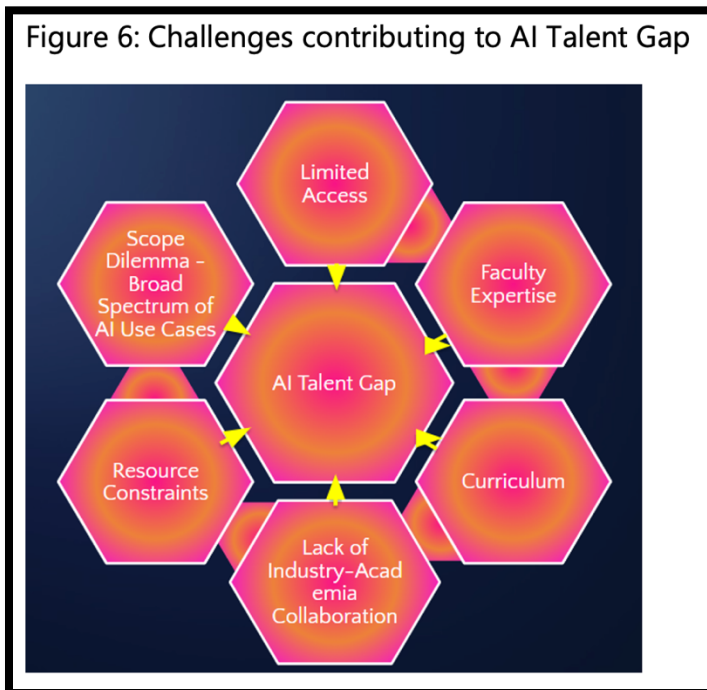
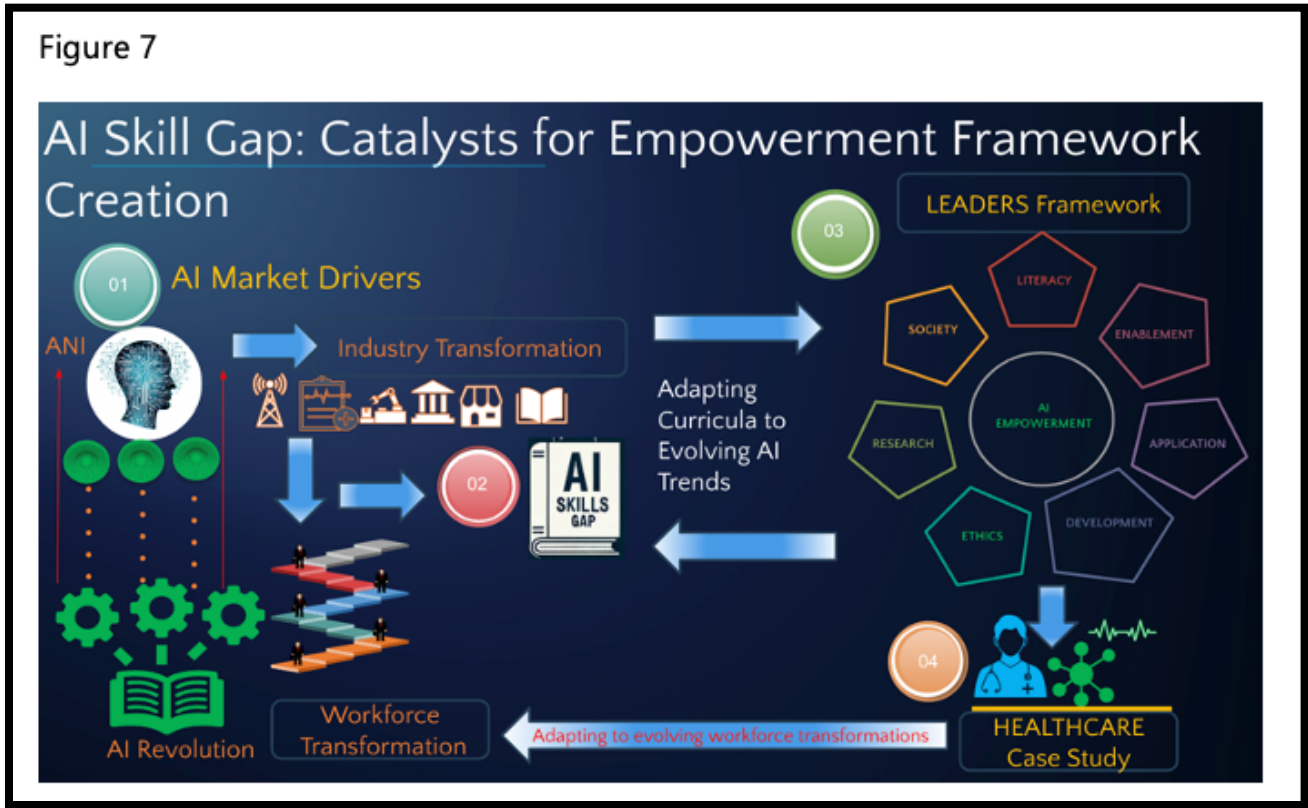


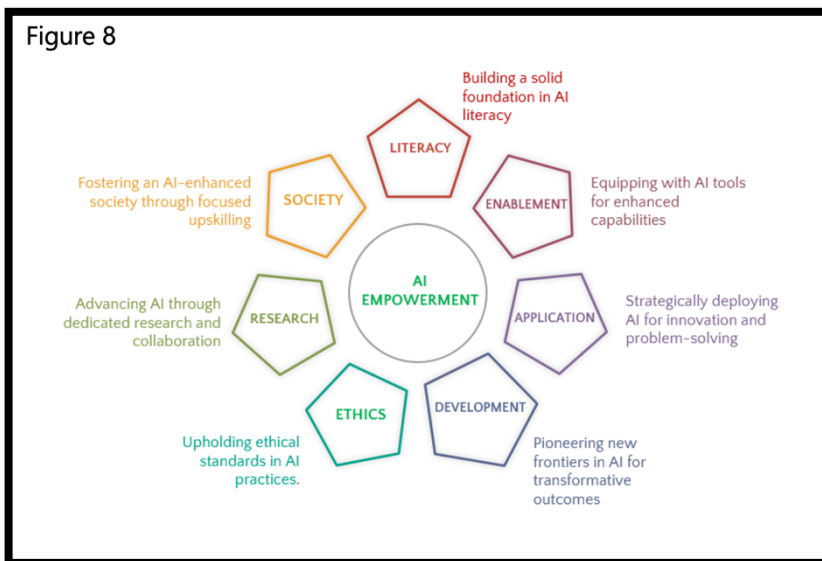
Figure 7



## The LEADERS AI Skills Framework

In the dynamic and ever-evolving landscape of Artificial Intelligence, the LEADERS framework emerges as a pathway for individuals and organizations aiming to navigate the complexities of AI adoption and skill acquisition. This framework is meticulously designed to provide a structured approach to understanding and mastering AI, ensuring that the workforce is not only proficient but also adept at leveraging AI technologies effectively.<sup>60</sup> The LEADERS framework transcends individual competency; it is a strategic asset for organizations seeking to foster an AI-ready culture.<sup>61</sup> **Emphasizing a holistic approach, from the fundamentals of AI literacy to the intricacies of implementation and**

**governance, the LEADERS framework (Figure 8) is a transformative journey towards responsible and innovative AI utilization.**<sup>62-63</sup>



In the quest to master the intricacies of AI, the LEADERS framework stands out as encapsulating seven pivotal pillars representing fundamental aspects of AI proficiency. This meticulously crafted framework can serve as a roadmap, guiding learners, educators, and industry professionals through the multifaceted journey of AI mastery.

- **L - Literacy:** Establishing a robust foundation in AI literacy, ensuring a solid understanding of core principles and potential applications across various sectors.
- **E - Enablement:** Empowering individuals and organizations to harness the power of AI through practical tools and methodologies.
- **A - Application:** Encouraging the strategic application of AI technologies to solve real-world problems and drive innovation.
- **D - Development:** Fostering a culture of continuous research and development to push the boundaries of what's possible with AI.
- **E - Ethics:** Prioritizing ethical considerations and responsible governance in the development and deployment of AI solutions.
- **R - Research:** Committing to in-depth research and community engagement to advance the field of AI and share knowledge.
- **S - Society:** Aiming for the creation of an AI-powered society where technology enhances daily life and societal functions.

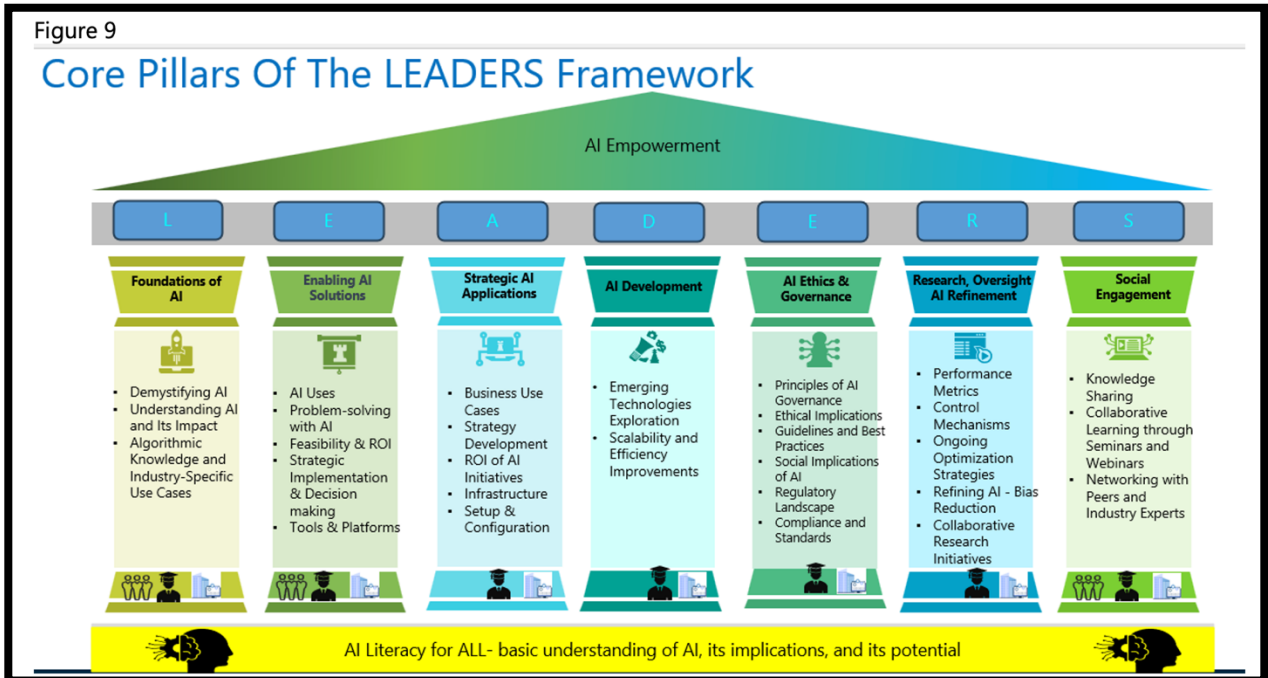


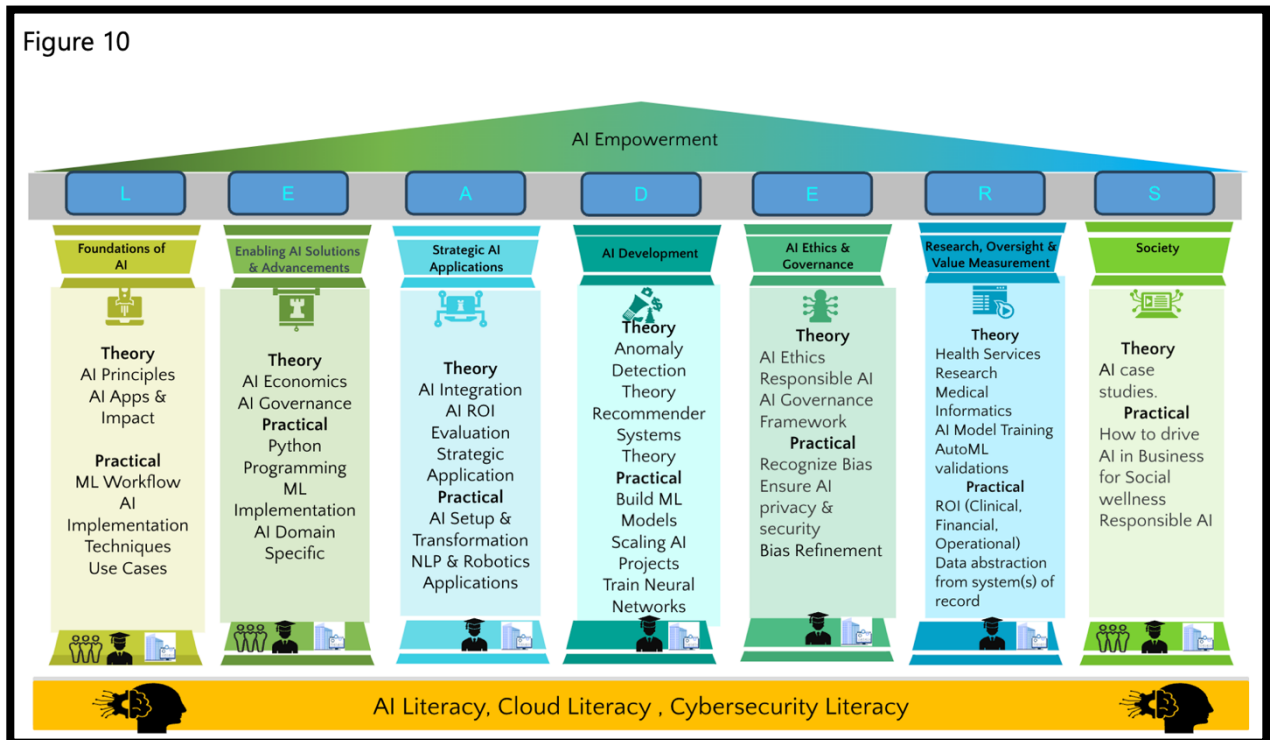
Figure 9 illustrates the pillars and the core principles. Then, as seen in Table 2, a delineation of how each pillar of the framework aligns with the specific needs and functions of different professional roles, from technical experts to leadership positions and traditional technologists looking to upskill in the realm of AI. This table serves as a guide to understanding which aspects of the framework are most pertinent to each role, ensuring a targeted and effective development path, based on whether theoretical and/or practical knowledge is needed.

Table 2: Roles across Industries utilizing LEADERS

Role Category	Specific Roles	Literacy	Enabling Tools	Application	Development	Ethics	Research	Strategy
AI Technology Roles	Machine Learning Engineers	√T,P	√T,P	√T,P	√T,P		√T,P	
	AI Data Scientists	√T,P	√T,P	√T,P			√T,P	
	Prompt Engineers	√T,P		√T,P	√T,P			
Leadership Roles	AI Translators	√T	√T	√T,P		√T,P	√T,P	√T,P
	AI Product Owners			√T,P		√T,P		√T,P
	AI Governance Leads					√T	√T,P	√T,P
	AI Leadership					√T	√T	√T,P
Traditional Technology Roles	Traditional Technologists	√T,P	√T,P	√T,P				
Individuals Scaling on AI	Individuals Interested in AI	√T,P		√T,P				√T,P

The checkmarks (√) indicate which pillars of the LEADERS framework are most applicable to each role. Some roles will benefit from multiple pillars, while others may focus on a few specific ones. T- refers to Theory, P - refers to Practical

Furthermore, Figure 10 divides up the pillars of the AI LEADERS framework into Theory vs Practical. The AI LEADERS framework is not just a tool; it is a transformative approach to shaping the future of AI competency and utilization. While it's evident that AI plays a crucial role in the current workforce and the importance of skilling cannot be overstated, it is equally imperative to address another profound aspect - the responsible use of AI, particularly with respect to ethics and governance.





## Key Principles of Responsible AI

In the rapidly evolving landscape of AI integration in healthcare, adherence to key principles of responsible AI is crucial. This section outlines a comprehensive framework that merges ethical considerations with the practical aspects of AI skills training, emphasizing the need for accuracy, transparency, fairness, safety, and security.<sup>64-65</sup>

1. **Accurate and Reliable AI Systems:** AI systems in healthcare should prioritize the development of accurate and reliable information. This not only fosters consumer trust but is essential for the responsible implementation of AI-enabled diagnostic tools and treatment plans.
2. **Accountable and Transparent:** Establishing guardrails and oversight procedures throughout the AI system's life cycle is imperative.<sup>66</sup> Compliance with government regulations and transparency into AI development ensures accountability and builds trust in the healthcare community.
3. **Fair and Human-Centric:** To mitigate discrimination and bias, AI developers must implement systems and guardrails that prioritize fairness.<sup>67</sup> The goal is to avoid undue hardships on various groups, ensuring healthcare AI benefits all members of society.
4. **Safe and Ethical:** The development of AI systems in healthcare should align with the goal of advancing and maintaining human life, individual health, and societal well-being.<sup>68</sup> Ethical considerations are paramount to prevent unintended harm and promote positive health outcomes.
5. **Secure and Resilient:** Cyber threats pose potential harm to AI systems in healthcare. Technical protections should be implemented to secure AI systems, ensuring resilience and the maintenance of patient data privacy and security.<sup>69</sup>
6. **Interpretable and Documented:** Transparency in AI operations is crucial. Healthcare practitioners and consumers should be able to understand AI decisions and limitations, promoting responsible AI principles and building trust in the technology.<sup>70</sup>
7. **Privacy-enhanced and Data-governed:** Compliance with privacy, security, and confidentiality regulations is non-negotiable. AI systems must be developed to adhere to data usage and retention standards, safeguarding patient information.
8. **Vendor and Partner Selection:** Oversight procedures should ensure fairness when selecting third-party vendors and partners involved in AI system development. This guarantees that healthcare AI is developed and implemented without bias.

"The diversity in the room while a model is developed affects the output. That's why DEI is an integral part of Responsible AI."

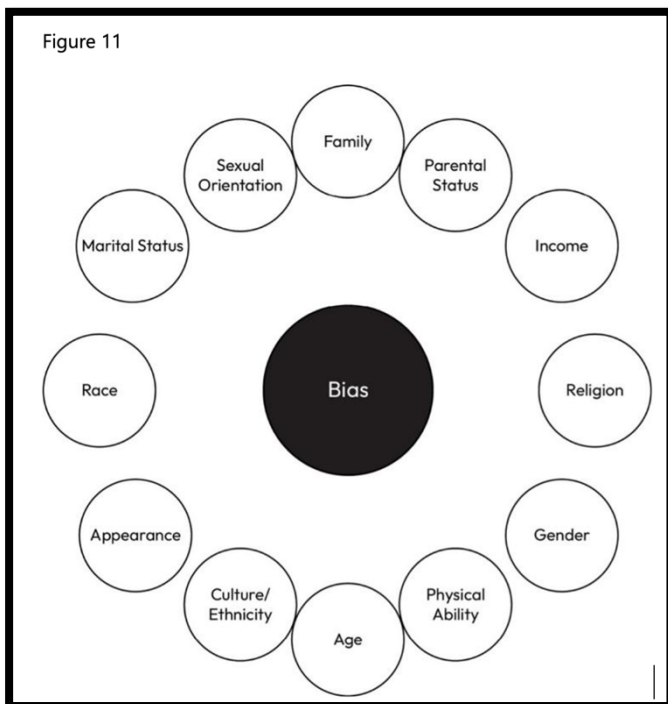
Noelle Russell, Accenture Global AI Solutions  
Lead and Microsoft MVP, AI

9. Ongoing Monitoring: Continuous monitoring and evaluation of AI systems are critical to ensure compliance with ethical, legal, and social standards.<sup>71</sup>
10. Guardrails should be in place to guarantee accurate and reliable outputs over time.
11. Continuous Learning and Development: AI systems in healthcare should undergo continuous learning, adaptive training, feedback loop adjustments, and compliance auditing. Regular updates and evaluations are essential to align with local and federal regulations and maintain reliability.

The Goal of Responsible AI Principles - The overarching goal of these responsible AI principles is to support the development and use of AI technology. By adhering to these principles, AI developers contribute to the improvement of societal needs, enhance consumer trust, and align AI products with ethical and fairness standards.

AI Risk: Mitigating Potential Harms - Despite the transformative potential of AI in healthcare, inappropriate use poses significant risks. This section addresses potential AI risks, focusing on bias and fairness issues, transparency, and the importance of ethical considerations.

1. Bias and Fairness: Biases within AI systems, particularly in healthcare, can perpetuate harmful stereotypes and prejudices.<sup>72-73</sup> Ensuring representative and unbiased datasets for AI training is essential to prevent biased outcomes, especially for underrepresented groups. See Figure 11.<sup>74</sup>



2. AI Transparency: To address the risks associated with AI use, comprehensive transparency measures are necessary. This involves understanding the underlying AI algorithms, facilitating troubleshooting, and rectifying biases and output discrepancies efficiently.<sup>75-76</sup>

3. AI Ethics, Alignment, and Reliability: Ethical guidelines are crucial for developing just, equitable, and unbiased AI models.<sup>77-78</sup> Aligning AI systems with human values and ethics is essential to mitigate risks and ensure reliable and trustworthy results.

Responsible AI use requires a multidimensional approach. From a healthcare perspective, accuracy and transparency to fairness and continuous learning, healthcare practitioners and

AI professionals must undergo rigorous training to navigate the complexities and ethical implications of AI integration. As AI in healthcare evolves, responsible AI principles and robust governance structures act as compasses, guiding the transformation for the betterment of society while minimizing potential risks.

## President Biden's Executive Order (EO): Safeguarding AI Development

President Biden's comprehensive Executive Order<sup>79</sup> on AI emphasizes the need for safe, secure, and trustworthy AI development. This section provides an overview of the EO's key principles and priorities, highlighting the role of the National Institute of Standards and Technology (NIST)<sup>80</sup> in developing guidelines for AI safety and standards.

1. **AI Safety and Security:** Standardized evaluations and risk mitigation mechanisms are crucial for ensuring AI safety and security. NIST plays a pivotal role in establishing guidelines for AI development, collaborating with other national agencies to identify and resolve potential flaws, vulnerabilities, and bias issues.
2. **Responsible Innovation and Competition:** The EO promotes responsible innovation, competition, and collaboration, addressing intellectual property rights and preventing monopolies to ensure a diverse and competitive AI landscape.
3. **Supporting American Workers:** The commitment to supporting American workers involves education, training, and understanding the impact of AI on the labor force. Ensuring a skilled workforce is essential for responsible and effective AI use.
4. **Advancement of Equity and Civil Rights:** AI policies must align with the advancement of equity and civil rights. The EO emphasizes the importance of preventing discrimination and ensuring fair AI practices.
5. **Privacy Protection:** Protection of the interests and privacy of Americans interacting with AI-enabled products is a priority. This includes ensuring lawful, secure, and privacy-centric collection, use, and retention of data.
6. **Data Security:** Ensuring lawful, secure, and privacy-centric collection, use, and retention of data.
7. **Federal Government Use of AI:** The federal government commits to managing risks from its own use of AI. Internal capacity for responsible AI use is enhanced, and federal agencies evaluate AI systems for potential risks and security concerns.
8. **Global Leadership:** Leadership in global progress involves engaging with international partners to develop a framework for managing AI risks. This collaborative approach ensures a global standard for responsible AI use.

The Executive Order (EO) introduces pivotal concepts aimed at shaping the responsible development of AI systems. A cornerstone of this initiative is the directive for the National Institute of Standards and Technology (NIST) to formulate guidelines ensuring the safety, security, and trustworthiness of AI. NIST's collaboration with national agencies, including

the Department of Energy (DoE), underscores the commitment to establishing standards and guardrails that address potential flaws, vulnerabilities, and biases in AI systems. Simultaneously, the EO mandates the creation of federal reporting requirements, facilitating the implementation of robust guardrails to ensure the safe and reliable development of AI for both consumer and private use.

Additionally, the EO entrusts the Secretary of Commerce (SoC) with the crucial task of gathering insights from diverse stakeholders, encompassing the private sector, public sector, and government entities. Through a comprehensive public consultation process, the SoC's investigation aims to identify potential risks and benefits associated with AI systems. Congress is expected to synthesize these findings to craft a comprehensive regulatory policy for AI systems, contributing to a well-informed and substantive approach.

At the intersection of national security and cybersecurity, the EO designates Infrastructure as a Service (IaaS) with the responsibility of alerting the SoC when foreign entities employ large AI models for malicious or cyber activities posing a national security risk. Moreover, companies developing AI models with the potential to impact national security or public health and safety are mandated to inform the federal government and share safety test results. Federal agencies are also tasked with evaluating AI systems and infrastructures to identify and mitigate potential risks and security concerns, further fortifying policies to address vulnerabilities in AI systems.

Notably, the EO not only assigns federal agencies to investigate risks associated with AI but also fosters an environment conducive to the growth and expansion of safe AI systems and tools. For example, the National Science Foundation (NSF) is directed to establish AI research tools, regional innovation engines, and AI research institutes. Additionally, the establishment of a Talent Task Force under the EO reflects a commitment to expedite the recruitment of skilled AI workers across the federal government, fostering innovation and expertise in this dynamic field.

### Incorporating Responsible AI at a Broader Scale

As the integration of AI becomes more prevalent across diverse sectors, including small businesses, industries, and academia, the necessity of local governance structures within these institutions becomes increasingly apparent. The implementation of responsible AI principles is not exclusive to large organizations; smaller entities must also navigate the complexities of AI integration with vigilance. Small businesses, industries, and academia play pivotal roles in societal development, and their adoption of local governance structures is essential for ensuring compliance with regulations and preventing unintended consequences.<sup>81</sup>

When incorporating AI on a broader scale, these entities face unique challenges and opportunities. Small businesses may encounter resource constraints, making it imperative to develop streamlined governance mechanisms that align with their operational scale.<sup>82-83</sup> Industries, with their diverse applications of AI, need tailored governance frameworks to address sector-specific risks and ensure responsible AI use. Similarly, academia, as a hub of AI research and education, must integrate local governance structures into their institutions to guide the ethical development and deployment of AI technologies.<sup>14, 84</sup>

Local governance within these entities should encompass principles such as accuracy, transparency, fairness, safety, and security. Adherence to responsible AI practices ensures that AI is utilized in ways that benefit communities, minimize risks, and align with societal values. As these entities embrace the transformative potential of AI, developing internal governance becomes not only a regulatory necessity but also a commitment to ethical and responsible innovation. The incorporation of AI at a broader scale necessitates a bottom-up approach, where local governance structures within small businesses, industries, and academia become integral components of the responsible AI ecosystem. These structures serve as safeguards, aligning AI use with ethical considerations, and ensuring that the positive impacts of AI are realized while mitigating potential pitfalls.<sup>81,</sup>

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In summary, Responsible AI use is a dynamic and evolving field that requires a robust framework of principles, continuous learning, and governance.<sup>74</sup> The fusion of ethical considerations with practical AI skills training ensures accurate, transparent, and fair AI systems that prioritize patient safety and well-being. President Biden's Executive Order further reinforces the commitment to safe and trustworthy AI development, emphasizing the need for standardized guidelines and collaboration across national and international agencies. As AI continues to redefine healthcare, responsible AI principles and governance structures stand as essential guardians, steering the transformative power of AI towards positive societal outcomes.

## Conclusion

Rethinking the current landscape of AI in academia and industry necessitates the cultivation of robust partnerships between academic institutions and industry stakeholders. A crucial step towards addressing the urgent need for AI skills in the workforce involves the integration of the AI LEADERS skills training framework. This framework provides a structured approach that aligns with industry demands, offering a pathway for immediate workforce training in AI.

The recommended strategies for enhancing collaboration between academia and industry underscore the transformative potential of these partnerships in the context of AI. Joint research initiatives, characterized by collaborative projects with clearly defined

“Industries should collaborate with universities to retain Computer Science professors. This partnership is crucial for nurturing future computer scientists and bridging the AI skills gap.”

—  
Atul Prakash PhD.  
Professor, Engineering and Computer Science  
University of Michigan

common goals, exemplify how academia and industry can propel scientific knowledge forward while addressing real-world challenges. Initiatives like the U.S. National Science Foundation's AI Research Institutes are at the forefront of driving such collaborative research efforts.<sup>86</sup>

Internship programs and industry placements play a pivotal role in providing students with valuable opportunities within industry settings. Fostering exchange programs between academia

and industry, as seen in the Google AI Residency, ensures that learners gain practical experience and exposure to real-world applications, bridging the gap between theoretical knowledge and practical skills.<sup>87</sup> The promotion of knowledge transfer from academia to industry, coupled with support for the commercialization of academic research, exemplified by initiatives like Neural Information Processing Systems (NeurIPS), facilitates the transformation of innovative ideas into marketable products and services.<sup>88</sup> This approach ensures that groundbreaking research conducted in academic settings finds meaningful applications in the industry.

Collaborating on industry-driven curricula and integrating guest lectures and workshops by industry professionals ensures that academic programs align with the rapidly evolving needs of the industry.<sup>89</sup> These collaborative efforts ensure that students are equipped with the skills and knowledge necessary to thrive in AI-related fields upon graduation. Hosting joint conferences, workshops, and seminars, as well as creating networking opportunities, fosters a dynamic exchange of knowledge between academia and industry. Initiatives like the FDA Digital Health Center of Excellence exemplify how such events provide platforms for meaningful discussions and collaborations between researchers, students, and

industry representatives. Facilitating access to industry resources, datasets, and computing power for academia enhances research capabilities and accelerates advancements. Collaboration through joint funding initiatives ensures that research projects receive the necessary support to make meaningful contributions to the field.

Collaborating on the establishment of ethical guidelines and addressing bias and fairness in AI algorithms, as evidenced by initiatives like the U.S. FDA's Digital Health Center of Excellence, ensures responsible and unbiased technology development. These collaborative efforts contribute to the development and deployment of AI in a manner that is aligned with ethical principles.

Establishing feedback mechanisms and advisory boards maintains ongoing communication between academia and industry. This adaptive approach allows for research focus adjustments based on industry needs, ensuring that academic efforts remain relevant and impactful. Developing clear policies on intellectual property (IP) ownership and negotiation agreements, as exemplified by initiatives like the Cedars-Sinai Accelerator, ensures transparency and fairness in collaborative projects. Such clarity promotes a conducive environment for fruitful collaboration between academia and industry.

Fostering long-term strategic alliances, such as the UK's NHS AI Lab, creates innovation hubs where academia and industry professionals collaborate on cutting-edge projects with enduring impacts. These strategic partnerships contribute to sustained advancements in AI, fostering a collaborative environment that drives innovation and positive change.

In conclusion, by adopting the AI LEADERS skills training framework and embracing these collaborative strategies, academia and industry partners can redefine the AI landscape. This synergy drives innovation, facilitates cutting-edge research, practical applications, and workforce development, ultimately ensuring that advancements in AI have a meaningful impact on both academic research and real-world applications in healthcare and beyond. The envisioned collaborations herald a future where mutually beneficial outcomes drive the responsible and ethical development of AI.

## CASE STUDY – Using the LEADERS framework for AI Skilling/Reskilling in the Healthcare Workforce

AI is significantly impacting healthcare. It can analyze and interpret extensive data, enhancing diagnostic accuracy, refining treatment plans, improving patient care, and accelerating medical research.<sup>90-91</sup>

However, AI adoption in the healthcare system could be delayed due to several reasons. Healthcare systems have been traditionally slow in adopting new technologies due to

numerous barriers. The cost is one major concern, as it includes not just the technology itself but also the costs of training staff, maintaining the system, and ensuring data privacy and security. Also, altering existing workflows to accommodate new AI systems can be disruptive and decrease productivity temporarily. Healthcare professionals, unfamiliar or uncomfortable with new technology, might resist this novel change. Crucially, integrating new technology into the notoriously complex hospital IT infrastructure can present significant challenges.<sup>92-94</sup> Lastly, navigating the web of regulatory requirements poses further hurdles. To overcome these challenges and benefit from AI advancements, hospitals should

run smooth change management processes. These processes should involve all stakeholders, provide adequate training, and communicate updates effectively.<sup>95-97</sup>

Training for AI implementation in the healthcare field is diverse and challenging. Medical professionals often lack the technical abilities required, and conversely, AI specialists often don't understand the specific needs of the healthcare domain.<sup>91,98-99</sup> To support successful adoption, users need not only to know how to work with AI systems but also to comprehend their function, possibilities, and limitations.

Key areas for successful training implementation include data privacy and security, ability to explain of AI decisions, handling limited or unstructured data sets, regulatory compliance, awareness of potential biases in AI decision-making, the practical implementation of new technology, and the establishment of standards for AI applications.<sup>100-101</sup>

"We're on a true inflection point of the way health care has to be. The key is that it must be managed in this country, partly because of workforce issues, partly because of obvious cost overruns. I believe that augmented intelligence meaning, not the computer dictating care, but the computer augmenting decision making and helping support the clinicians at the bedside with improved real time insights is no longer a theory but is going to be an implicit capability and mandate that's going to help drive care in the next decade."

Gurmeet Sran, MD, MS,



Using the AI LEADERS framework, we propose a comprehensive AI skills training program. This program caters to a wide range of roles within a healthcare setting. It serves patients, front desk staff, nurses, clinicians, clinical researchers, administrators, executives, data scientists, billing and legal department personnel, HR staff, and software programmers. Each of these roles will interact with AI in unique ways and thus require tailored training. The program can be implemented in any healthcare facility, from community-based hospitals to academic medical centers, making it highly versatile and beneficial.

"In order to first do no harm, healthcare providers who are inherently conservative, must first work with technologically mature vendors to adopt AI tools while the health systems then work within to learn to generate their own AI enablement as needed."

Andrew Rosenberg MD, Chief Information Officer,  
Michigan Medicine - University of Michigan

We present a journey of a patient, Daniel (Figure 12)– showcasing the power of a skilled AI workforce in action in the healthcare setting. This has the potential to accelerate patient care and satisfaction on multiple levels.<sup>102-107</sup>

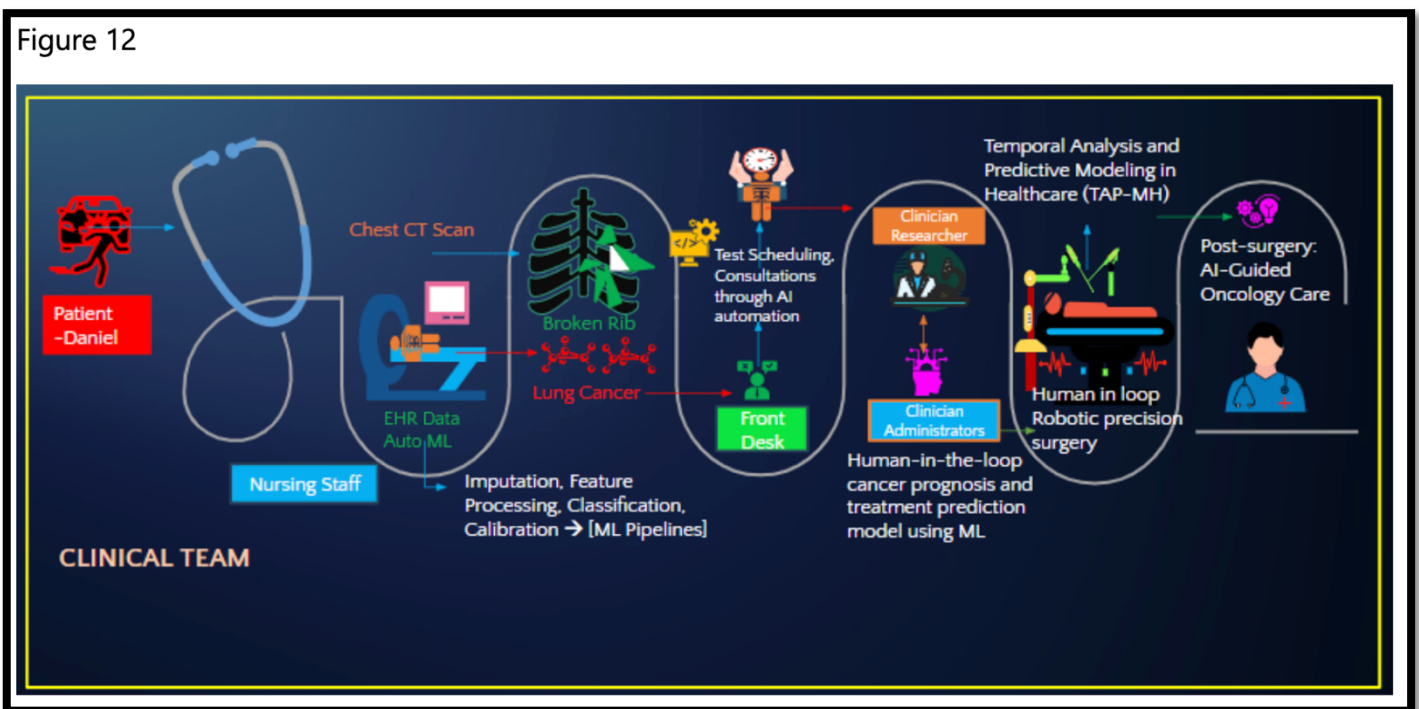
*Daniel, a 58-year-old high school math teacher, was in a car accident and had a broken rib that required care at his local emergency room. He underwent a CT scan of the chest and was treated for the fracture. An AI early detection radiology tool flagged his scan for a suspicious lung nodule. This eventually led to a diagnosis of stage II lung cancer. He was shocked as he is a lifetime nonsmoker and has always taken care of his health. Amidst this uncertainty, a journey unfolds for Daniel as a cancer patient, revealing the potential of precision medicine and AI capacity in shaping his diagnosis and treatment. Daniel was referred to a well reputed hospital known for its cancer treatment program to be seen by a thoracic surgeon.*

*Behind the scenes, even before Daniel's first appointment, Rachel, the scheduler, orchestrates Daniel's appointments with the finesse of an artist, leveraging AI-driven scheduling systems to ensure the seamless flow of consultations, tests, and treatments. Her mastery lightens the load on patients, creating a more navigable path through the complex web of healthcare. It limits multiple trips for him and allows him to navigate his appointments in his busy schedule. Daniel is first seen by Dr. Shah and undergoes surgical removal of his cancer. Preoperatively, AI tools analyze scans and medical history records to assist in planning surgical procedures, determining the best surgical approach, predicting possible complications, and estimating patient recovery time. Furthermore, AI devices, including robotic surgical systems, are then used during surgery to increase precision, stability, and dexterity. AI image recognition systems assist in real-time during surgery for*

identifying vital structures, differentiating between healthy tissue and tumors, etc. This results in less pain, less blood loss, and quicker recovery time for Daniel.

In the realm of clinical cancer research, Dr. Walker (cancer data informatics specialist) sifts through vast datasets using AI, seeking patterns and potential breakthroughs in lung cancer treatment. He works with a team of data scientists like Lewis, who meticulously analyzes large datasets using AI, deriving insights that inform clinical decision-making. **Their discoveries become rays of hope, contributing to the ever-evolving landscape of precision medicine. Detailed pathologic review and analysis of Daniel's tumor, using AI predictive tools, determines that there is up to 30% risk of cancer recurrence and chemotherapy is advised.**

Figure 12



Dr. Reynolds, a thoracic medical oncologist, then emerges as a central figure in Daniel's journey. She utilizes AI based tools in the clinic to quickly generate visit reports and answer Daniel's messages on the medical records portal. Armed with Dr. Walker's AI algorithmic tools, she delves into the intricacies of Daniel's genomic data. This detailed analysis serves as her compass, guiding her in selecting the precise targeted therapies tailored to the unique characteristics of Daniel's cancer. The precision introduced by AI not only enhances treatment efficacy but also minimizes potential side effects. During treatment, Oncology nurse Olivia vigilantly monitors Daniel's vital signs and treatment responses. The real-time alerts from the AI monitoring system empower Olivia to intervene promptly, enabling her to personalize Daniel's care with a keen understanding of the dynamic nature of his condition.

*Dr. Rodriguez, the cancer clinic's medical director, oversees the implementation of AI tools in patient care. Emphasizing the importance of AI skills training for the medical staff, she ensures that they are well-prepared to harness cutting-edge technologies in their daily practice.*

*Kevin, the HR manager, working with administrators and medical directors, plays a pivotal role in ensuring that all hospital staff, from frontline workers to medical professionals, undergo AI skills training. His proactive approach guarantees that employees are confident and competent in utilizing AI tools to enhance patient care. Billing specialist Jessica streamlines processes using AI-powered billing systems, not only resulting in accurate billing but also alleviating financial stress for patients like Daniel, ensuring a smooth financial process for the hospital by financial forecasting using AI tools. Michael, the legal counsel, ensures the hospital adheres to legal and ethical standards in AI use. His crucial role in crafting policies protects patient data privacy and maintains transparency in AI applications for the responsible use of AI throughout the system.*

*Alex, the IT manager, and software engineers Emily and Harris spearhead the integration of AI technologies into the hospital's IT infrastructure. Their ongoing support to medical staff ensures that AI systems operate seamlessly, contributing to efficient patient care. They manage the data lake for the health system integration. Additionally, AI-based cybersecurity tools scrutinize network behavior, flag any suspicious activity, and enable a prompt, early, and targeted response.*

*The hospital's CEO, Sarah, passionately advocates for the widespread adoption of AI technologies. She serves as a change leader during this dynamic time. Recognizing the transformative impact of AI in healthcare, she throws her support behind comprehensive hospital system wide change and training requirements for the hospital staff.*

Daniel's cancer journey, shaped by the collaborative efforts of these roles and fueled by AI capacity and training, showcases the transformative potential of technology in healthcare. Through the integration of precision medicine and AI, Daniel and patients like him find renewed hope on their challenging path to recovery.

In the following section, we delineate the principal roles within a healthcare system and illustrate how the LEADERS framework can be utilized. We elaborate on the specific AI training that would be required for each role to fully leverage AI capabilities, thereby maximizing the potential benefits of this technology in the healthcare sphere.

**Patient** - As the integration of AI into healthcare continues to grow, it is increasingly important for patients to acquire a foundational understanding of these technologies to navigate their healthcare experiences more effectively. This involves several aspects of AI literacy and skills that patients may find beneficial.

Firstly, patients should develop a basic familiarity with AI and its potential impact on healthcare. Recognizing AI as a tool employed by healthcare providers for decision-making, diagnosis, and treatment planning is essential. Additionally, patients need awareness about data privacy, understanding how their personal health data is utilized and the safeguards in place to protect their privacy. This includes being informed about their rights regarding data access permissions.

“Patient data has historically been disparate and disconnected in a clinical setting. Patient-generated data from multiple sources compounds this problem. We have a greater opportunity than ever before to create a comprehensive picture of a patient, but that can only be realized with the application of AI to assemble relevant patient and population data to achieve high-quality care.”

Ami Bhatt MD, Chief Innovation Officer,  
American College of Cardiology,  
Associate Professor of Internal Medicine,  
Harvard Medical School

Given the expanding role of AI in the health sector, patients are likely to interact with AI technologies more frequently. This interaction could encompass using AI chatbots for appointment scheduling, utilizing AI applications for health monitoring, or engaging with AI-driven telemedicine platforms. Therefore, patients should be equipped with the skills to navigate and make effective use of these technologies.

Understanding the outputs generated by AI systems is crucial for patients. For instance, if an AI tool predicts the risk of a certain disease, patients need to comprehend these predictions and determine appropriate responses. While appreciating the potential benefits of AI, patients should maintain critical thinking, recognizing that AI complements human judgment and medical advice rather than replacing it.

Adaptability is key, considering the constant evolution of AI technologies. Patients who are comfortable with technological changes and open to learning and adapting to new systems will likely benefit the most from advancements in healthcare technology.

While patients may not be expected to grasp the technical intricacies of AI algorithms, having a basic familiarity with AI's role in healthcare can foster a sense of comfort and empowerment. Healthcare institutions play a pivotal role in providing basic AI literacy to patients, like the understanding of patient privacy rights. Documentation of patient

understanding of AI rights may be necessary, aligning with broader AI governance initiatives on a large scale.

**Front desk staff**, encompassing receptionists, schedulers, and administrators, hold pivotal positions in healthcare delivery, directly interacting with patients. Equipping them with relevant AI skills is essential to enhance their roles in this dynamic environment.

Firstly, fostering AI familiarity among frontline staff is crucial. An understanding of what AI is and its applications in healthcare provides context for their work and underscores its potential impact. This includes knowledge about AI-powered tools pertinent to their roles, such as appointment scheduling systems, electronic health record systems, and automated billing/insurance tools.

Given their daily interactions with AI systems, proficiency in software operation is paramount for frontline staff. Whether using AI-enabled scheduling systems to book appointments or troubleshooting basic issues, software competency is integral to their responsibilities. The accurate and consistent entry of patient data is a core responsibility for frontline staff, recognizing its importance for the efficacy of AI algorithms. Data entry and management skills contribute to the generation of high-quality data upon which AI systems rely.

Understanding the rules governing data privacy and security is particularly pertinent for front staff, who often manage sensitive patient data at the forefront of data management processes. Interacting with AI tools necessitates an understanding of AI outputs and predictions. Frontline staff must be adept at interpreting these outputs, such as automated alerts in electronic health record systems, and taking appropriate actions based on them.

Effective communication skills are invaluable for front staff, as they may need to explain AI processes to patients. This includes elucidating how virtual assistants work or clarifying the use of automated calling systems, highlighting the importance of communicating about technology in a comprehensible manner.

Given the evolving nature of AI technologies, adaptability is a key attribute for front desk staff. Being comfortable with learning and integrating new technologies ensures that they can effectively navigate evolving roles in tandem with technological advancements.

While an in-depth understanding of AI algorithms is not required, frontline staff stand to benefit significantly from grasping how to use AI-powered tools effectively, appreciating

the ways AI can aid in their tasks, and communicating about AI in a manner that aligns with their roles and responsibilities.

**Nursing staff** serving as frontline healthcare workers play a crucial role in delivering substantial patient care. With the integration of AI into healthcare, it becomes imperative for nurses to comprehend the essence of AI and harness its capabilities. Several key AI skills can prove beneficial in augmenting their roles in patient care.

To begin, nurses should cultivate foundational AI familiarity. This involves acquiring knowledge about what AI is and how it can be applied in healthcare, with a specific focus on its relevance to nursing and its potential to enhance patient care.

Technological proficiency is essential as nurses often engage with AI-powered tools in their daily tasks. From electronic health record systems to automated vital sign monitors and predictive analytics tools for risk assessments, nurses should be adept at operating and navigating these tools seamlessly.

The ability to interpret outputs from AI models is crucial for making informed decisions. For instance, understanding alerts generated by predictive models identifying patients at risk of a deteriorating condition empowers nurses to respond effectively to potential issues. Equally important is data management, where nurses contribute significantly by inputting accurate and comprehensive data into AI tools. Recognizing the significance of their role in data collection enhances the efficacy of AI applications.

Nurses need a clear understanding of data privacy rules associated with AI tools handling patient data. Familiarity with the measures in place to safeguard patient data and awareness of potential risks is vital to maintaining ethical standards. While AI can provide valuable insights, it is crucial for nurses to retain their critical thinking skills. AI supports human decision-making but cannot replace the professional judgment, skills, and experience of nurses in patient care.

Effective communication about AI is another key skill for nurses, enabling them to explain the role of AI in patient care to both patients and their families. This includes clarifying how patient data is used and addressing any concerns or questions to build trust. **Adaptability is paramount as AI capabilities continue to advance rapidly. Nurses must remain open to learning and adaptable to change, recognizing that the tools used in healthcare may evolve over time. Although nurses are not expected to code or delve into the deep complexities of AI, a clear understanding of how AI fits into their workflows and how it can assist them in providing patient care is essential for leveraging its potential benefits.**

**Clinicians** dedicated to day-to-day patient care, can significantly elevate their practice by prioritizing AI literacy, ethical considerations, refinement of AI models, and an understanding of societal implications in their skills training.

Firstly, cultivating AI familiarity is foundational. This involves developing a basic understanding of what AI encompasses, the diverse types of AI, and potential use cases in healthcare. This emphasis on AI literacy equips clinicians with the knowledge to navigate the evolving landscape of AI technologies. Data interpretation is a crucial skill that emphasizes the importance of understanding the output provided by AI systems. Clinicians need to be adept at interpreting diagnostic recommendations, risk assessments, and predictive analyses. This skill enables them to better assess patient conditions and tailor appropriate treatment strategies.

Proficiency in operating specific AI tools integrated into clinical workflows is essential. This encompasses AI-powered electronic health records, imaging analysis software, predictive analytics tools, and decision support systems. Training in tool operation ensures clinicians can seamlessly integrate AI into their daily tasks. The emphasis on data privacy and security underscores the importance of clinicians having knowledge about how patient data is used, shared, and protected within AI tools. Understanding the regulations and ethical considerations surrounding data usage is integral to responsible AI integration in healthcare.

Critical evaluation skills are paramount for clinicians. This involves the ability to critically assess AI models and tools, including understanding their limitations, biases, and potential errors. Such skills empower clinicians to make informed decisions about the use of AI tools based on their clinical expertise.

Staying abreast of advances in AI technology is essential for clinicians. This continuous learning approach ensures they remain informed about the latest advancements, best practices, and regulatory changes pertaining to AI use in healthcare. Effective communication about AI applications to patients is a crucial aspect of skills training. Clinicians should be equipped to explain how AI impacts patient care, the usage of patient data, and address any concerns patients might have. This skill fosters trust and transparency in the adoption of AI technologies.

"Physicians won't be replaced by AI, but physicians that don't use AI will be replaced by those who do."

David Vawdrey PhD,  
Chief Data Informatics Officer, Geisinger

In skills training for clinicians, while they do not need to become data scientists, a foundational understanding in these areas—AI literacy, ethical considerations, refinement of AI models, and awareness of societal implications—equips them to seamlessly integrate AI tools into their practice. This not only enhances patient care but also ensures clinicians can effectively communicate about the responsible use of AI with their patients.

**Clinical Researchers** particularly those engaged in clinical research areas such as precision medicine that involve extensive data usage, require an advanced set of AI skills. In skills training for clinician researchers, there is a notable emphasis on AI literacy, ethics, regulations—especially when conducting clinical trials using AI—and the enablement of AI within clinical settings with the creation and refinement of AI models. Moreover, an understanding of societal implications is integral to comprehensive skills training for clinician researchers.

A foundational aspect of AI literacy for clinician researchers involves acquiring a deep understanding of various AI concepts, methodologies, and the effective utilization of AI in clinical research, particularly within precision medicine. This advanced comprehension is crucial for navigating the intricacies of AI applications in research settings.

Ethical considerations and adherence to regulations take center stage in the skills training for clinician researchers. This is especially pronounced when conducting clinical trials using AI, as the ethical use of patient data forms the backbone of precision medicine research. Clinical researchers must possess a profound understanding of the ethical considerations and regulatory frameworks governing the use of patient data in their research endeavors.

The enablement of AI in a clinical setting through the creation and refinement of AI models is a key aspect of skills training. Clinical researchers need to be adept at handling large, complex datasets commonly encountered in precision medicine research. Skills such as data cleaning, managing missing data, and addressing outliers are essential, along with a basic understanding of data architecture and database management. In the realm of data analysis and interpretation, clinical researchers must acquire the ability to design, run, interpret, and validate AI models, including Machine Learning and Deep Learning algorithms. Statistician skills are particularly valuable as these professionals need to comprehend the metrics used to evaluate the performance of AI models in research settings.

Algorithm comprehension is another critical facet of skills training for clinician researchers. Understanding how different algorithms function and discerning when to use them is indispensable. This knowledge enables clinicians to leverage the strengths and mitigate



the weaknesses of various AI models, facilitating the selection of the most appropriate model for a given research study.

Effective communication skills, specifically in scientific writing, are essential for clinical researchers. The ability to translate complex AI analytics into understandable language for diverse audiences, including peers, patients, and other stakeholders, contributes to the dissemination of research findings and promotes broader understanding.

Staying current with advances in the rapidly evolving field of AI in healthcare is a continuous requirement for clinician researchers. Adeptness at staying informed about recent advancements, methodologies, and tools ensures that clinical researchers maintain the highest standards in their research endeavors.

In conclusion, skills training for clinical researchers should encompass a comprehensive foundation in AI literacy, ethics and regulations—particularly in the context of clinical trials using AI—enablement of AI in clinical settings through model creation and refinement, and an understanding of societal implications. This multifaceted approach equips clinical researchers to integrate AI ethically and effectively into their precision medicine research.

**Clinician Administrator/Manager**, exemplified by the medical director of a clinic in a leadership role, requires a comprehensive understanding of AI from both strategic and operational perspectives. The skills training needed for clinician administrators goes beyond basic AI awareness, encompassing a multifaceted approach that emphasizes AI literacy, enablement, application, development, ethics and regulation, research and refinement, and the societal impact of AI adoption in healthcare.

AI literacy is foundational, requiring a nuanced understanding of what AI entails, its possibilities, and limitations. For clinician administrators, this literacy extends to comprehending how AI can be specifically applied in their field and the potential transformative impact on healthcare delivery. Enablement skills are vital for clinician administrators, focusing on the ability to strategically visualize and integrate AI into the clinic's workflow to enhance operational processes. This includes decision-making on the adoption of AI tools or applications based on the clinic's unique needs, budget constraints, and technical resources.

Application skills involve the capability to understand and interpret AI outputs relevant to the clinician administrator's leadership role. While not directly involved in data analysis, this skill set extends to interpreting data analytics reports to inform effective decision-making processes within the clinic.

Development skills are crucial for clinician administrators to navigate the regulatory landscape, understand privacy issues, and grasp the ethical implications surrounding the

use of AI in healthcare. This involves awareness of how patient data is used, stored, and secured within AI systems, aligning with the broader ethical considerations of AI usage. Research and refinement skills are integral for clinician administrators, enabling them to stay informed about the latest advancements in AI technology, methodologies, and tools. This ongoing education ensures that clinical administrators can drive AI adoption while maintaining the highest standards in their healthcare facility.

The societal impact of AI adoption necessitates a vision for integration that aligns with the clinic's mission and vision. Clinician administrators play a pivotal role in communicating this vision to the team, fostering the adoption and acceptance of AI technology within the clinic and its broader societal context. Understanding the financial considerations of AI implementation is a critical aspect of skills training for clinician administrators. This involves managing budgeting and resource allocation, comprehending the return on investment (ROI), and understanding the financial implications of AI implementation, including costs related to operation, maintenance, and training.

Continuing education and staying updated with AI advancements are essential components that reinforce these skills for clinician administrators. This holistic skills training approach equips them to effectively drive AI adoption in their healthcare facility, ensuring a transformative and ethically sound integration of AI in clinical leadership.

**Data Scientists** in healthcare and hospital systems play a pivotal role in the development, implementation, and management of AI tools. The extensive and technical nature of their AI skill requirements encompasses a diverse range of competencies. In skills training for healthcare data scientists, there is a critical emphasis on AI literacy, enablement, application, development, ethics and regulation, research and refinement, and the societal impact of their work.

AI literacy is foundational, requiring a deep understanding of algorithm development and validation. Data scientists must be adept at developing and validating machine learning and deep learning algorithms, making informed decisions on when to apply each type and optimizing their performance. Enablement skills involve the capability to prepare data effectively, recognizing the challenges posed by real-world healthcare data that is often fragmented and unstructured. This includes robust skills in data preprocessing, encompassing data cleaning, handling missing values, and the selection of relevant data for analysis.

Application skills demand proficiency in statistical analysis, as statistical methods inform various aspects of AI, from model selection to understanding outputs. Strong statistical

skills are crucial for healthcare data scientists to derive meaningful insights from healthcare data.

Development skills encompass programming knowledge in languages such as R, Python, SQL, and others commonly used in data science and AI. This technical proficiency enables data scientists to implement and optimize AI models effectively.

Ethics and regulation awareness are integral components of skills training for healthcare data scientists. Understanding the ethical considerations of AI work and compliance with data privacy regulations, especially when dealing with sensitive healthcare data, are paramount in ensuring responsible and ethical AI practices.

Research and refinement skills involve staying updated with AI trends and advancements, considering the rapid evolution of the field. Healthcare data scientists need to continuously learn new methods, tools, and best practices to remain at the forefront of AI in healthcare.

The societal impact of AI work is a focal point, necessitating effective communication skills. Data scientists must be able to communicate complex AI concepts to non-technical stakeholders, facilitating data-driven decision-making and fostering a broader understanding of their work in the healthcare context. Working closely with medical professionals and understanding the clinical context is emphasized for healthcare data scientists. This collaborative approach ensures the development of AI solutions that are practical, beneficial, and aligned with the unique challenges and nuances of the healthcare setting.

In conclusion, skills training for data scientists in healthcare spans a comprehensive framework that includes AI literacy, enablement, application, development, ethics and regulation, research and refinement, and understanding the societal impact of their work. This approach equips healthcare data scientists to navigate the complexities of their field responsibly and effectively.

**Legal** professionals within the healthcare sector play a critical role in navigating complex legal and regulatory landscapes. As AI becomes more prevalent, these professionals will also have to understand how AI intersects with legal issues. Here are some of the AI-related skills they might need. AI Familiarity is foundational, requiring legal professionals to understand what AI is, how it operates, and the interaction between AI and the law. This includes knowledge of the different applications of AI in healthcare and the legal considerations each application might entail.

AI Ethics and Regulations are crucial areas for legal professionals to master. They need to understand the legal and ethical implications of using AI in healthcare, such as privacy issues, data protection regulations, and the necessity of informed consent. This understanding should extend to both national and international laws governing AI.

AI Contract and Compliance Management skills are essential for lawyers dealing with AI in healthcare. They must know how to draft, review, and negotiate contracts involving AI tools, ensuring that AI adoption and usage within the hospital comply with relevant laws and regulations.

Understanding the intersection of Intellectual Property (IP) laws and AI is vital. With AI being used to create tools, algorithms, and content, legal personnel need to comprehend how intellectual property laws apply to these AI-generated assets.

Liability and AI knowledge is imperative as AI is increasingly used for decision-making in healthcare. Lawyers need a clear grasp of malpractice laws as they relate to AI, understanding who holds responsibility in the event of mistakes.

Data Governance understanding is crucial, involving knowledge of rules around data usage, how AI impacts these rules, and the legal and ethical implications of AI's data usage. Critical Evaluation skills are necessary for lawyers to assess new AI solutions critically. They need to consider the legal implications of AI while balancing the benefits these technologies may bring to healthcare. Staying Updated is a continuous requirement for legal professionals, given the evolving legal landscape surrounding AI in healthcare. They should stay current on new laws, regulations, and court decisions that pertain to AI in healthcare.

The AI literacy needs of legal personnel do not necessarily include the technical workings of AI. Instead, the focus is on the legal, ethical, and regulatory aspects of AI implementation and usage. While they might not need to know how to build an AI model, they do need to understand, for example, who owns that model. Skills training for legal professionals should emphasize AI literacy, ethics governance, and the societal impact of AI in healthcare.

**Human Resources (HR)** department plays a vital role in staffing, training, and compliance. As AI integration becomes increasingly prevalent in the healthcare environment, HR professionals need to acquire basic AI literacy to effectively fulfill their responsibilities. Several AI-related skills are particularly beneficial for their roles.

AI Familiarity is foundational, requiring HR personnel to have a basic understanding of AI and its applications in healthcare. This includes familiarity with AI-powered HR tools used for tasks such as hiring, job matching, workforce planning, and employee training.

Proficiency in AI Tool Operation is essential, as HR professionals will need to effectively use AI-powered tools relevant to their role. This may involve utilizing AI systems for tasks like resume screening, job matching, and predicting employee performance.

Understanding Data Management is crucial, given that AI systems rely on data for effective functioning. HR professionals should grasp data management principles, including a comprehensive understanding of data privacy laws and their application to employee data.

The ability to Understand AI Outputs is a necessary skill for HR professionals, enabling them to accurately interpret and act on predictions and analytics provided by AI systems. This involves using insights from AI systems analyzing employee performance data, for instance. Ethics and Bias Awareness is imperative, as HR professionals need to understand how unconscious bias can be ingrained in AI algorithms. They should be aware of the ethical implications associated with using AI in decision-making processes.

Implementation and Change Management skills are vital as AI technologies become integrated into the HR landscape. HR professionals should be adept at managing the adoption process of such technologies, including training employees and addressing potential resistance.

Data Privacy and Security knowledge is essential, considering HR deals with sensitive employee data. HR professionals should be well-versed in data protection regulations and understand the implications of data security in AI applications. Adaptability is a critical skill, given the rapidly evolving landscape of AI. HR professionals need to be flexible and capable of adapting to new software, techniques, and workflows associated with AI. Combining these skills empowers HR personnel to effectively utilize AI in their roles while minimizing potential risks.

**Billing department personnel** in a healthcare setting predominantly deal with financial transactions and insurance processes. AI has the potential to render many aspects of their job more efficient. Here are some AI skills that could be relevant.

AI Familiarity is foundational, requiring a basic understanding of AI and its potential applications in healthcare, specifically in the billing department. This includes understanding AI-powered financial tools, such as automatic billing systems and predictive analytics for revenue cycle management.

AI Tool Operation is crucial for employees to be trained in using AI-enabled tools proficiently and efficiently in their department. This includes billing software, financial data analysis platforms, automated coding systems, and potential AI-based fraud detection systems. Data Entry and Management skills are important as AI systems rely on accurate

data. Being able to input data consistently and accurately is crucial. An understanding of how AI uses and learns from this data would also be beneficial.

Data Privacy and Security awareness is essential, especially as billing department personnel work with sensitive financial information. Understanding how to mitigate any risk associated with the AI tools they use is crucial for maintaining data privacy and security.

Understanding AI Outputs is a necessary skill for billing department personnel. They should be able to accurately interpret any AI outputs related to their role, such as reports generated by AI regarding productivity, revenue cycles, and discrepancies in billing. Adaptability is vital since the functionalities of AI-powered tools might change with updates, and AI technologies in healthcare are continuously evolving. Being comfortable with these changes and adapting to them quickly is crucial for efficient workflow.

Critical Thinking remains crucial for billing department staff despite the assistance AI provides. They should critically evaluate the inputs and outputs of the AI tools to mitigate potential errors, such as erroneous patient billing due to misclassifications by AI coding tools. Emphasizing AI literacy and ethics is paramount in the training of billing department personnel. Understanding the ethical implications of AI usage and ensuring a high level of literacy regarding AI technologies will contribute to responsible and effective implementation in the billing department.

**Healthcare IT personnel** are integral to the successful implementation of AI in a hospital setting, with responsibilities ranging from managing IT infrastructure to integrating new digital solutions. The skills training for these professionals is extensive, emphasizing AI literacy, enablement, application, development, ethics and regulation, research and refinement, and the broader societal impact of AI in healthcare.

AI literacy serves as the foundation, requiring IT professionals to have a robust understanding of AI, machine learning, and deep learning, along with their specific applications within the healthcare sector. This foundational knowledge equips them to navigate the intricacies of AI-powered systems. Enablement skills involve technical proficiency, including competence in using AI-powered software and hardware. Familiarity with coding in languages commonly used in AI, such as Python, Java, or R, is crucial for effective implementation and troubleshooting.

Application skills encompass the ability to manage and organize vast sets of data, a critical aspect of AI operation. IT professionals need to understand database design, data structuring, and how to manage, process, and store large datasets efficiently.

Development skills in system integration are vital, focusing on understanding how to integrate AI applications with the existing IT infrastructure. Ensuring compatibility and

interoperability with systems like Electronic Health Record (EHR) systems is integral to seamless operation.

Ethics and regulation awareness are crucial components of skills training for IT personnel. Knowledge of data security frameworks and standards, particularly those governing sensitive healthcare data, is essential for protecting data confidentiality, integrity, and availability. Research and refinement skills involve understanding algorithm implementation, including how AI algorithms are developed, implemented, and interact with end-users and other hospital systems. This knowledge contributes to the continuous improvement of AI applications. The impact of AI on network and cloud infrastructure necessitates skills in understanding how AI applications interact within these environments. Many healthcare AI solutions operate in the cloud, requiring IT personnel to navigate these systems effectively. Troubleshooting and maintenance skills are core aspects of the role, involving dealing with technical issues, ensuring AI systems are up-to-date, and maintaining their smooth operation for optimal functionality.

Regulatory compliance awareness is integral, involving understanding regulations around the use of AI in healthcare, such as HIPAA in the United States or GDPR in the EU. Compliance ensures ethical and legal AI practices. Continuously keeping abreast with AI trends is essential for IT personnel, given the rapid evolution of the field. Staying current with new technologies, standards, and best practices ensures that IT professionals can effectively contribute to a hospital's AI readiness.

In conclusion, the skills training for healthcare IT personnel is a comprehensive and multifaceted approach that encompasses AI literacy, enablement, application, development, ethics and regulation, research and refinement, and an understanding of the broader societal impact of AI in healthcare. This holistic training equips IT professionals to navigate the dynamic landscape of AI implementation in a hospital setting responsibly and effectively.

**Healthcare executives**, including CEOs and CIOs, hold strategic roles in the administration of hospitals or medical centers, influencing the overall direction and efficiency of healthcare services. Skills training for these executives is integral, emphasizing AI literacy, enablement, application, development, ethics and regulation, research, and refinement, and understanding the broader societal impact of AI in healthcare.

AI literacy serves as the foundation, requiring executives to understand the basics of AI and its implications for healthcare. This encompasses knowledge about different types of AI technologies, their specific uses, and the potential impact on patient care, research,

and administrative tasks. Enablement skills are crucial for strategic planning, empowering executives to envision and plan how AI can be strategically incorporated into the entity's services. This involves improving care quality, enhancing efficiency, and optimizing outcomes through the thoughtful integration of AI.

Application skills demand cognizance of AI's limitations and risks, including issues related to privacy, bias, and malfunctions. Executives need to understand these potential challenges and be equipped to mitigate threats effectively. Development skills involve budgeting and resource allocation for AI implementation. Executives play a pivotal role in assessing the potential costs and benefits, encompassing initial installation costs, ongoing maintenance costs, and the costs associated with training staff for AI integration.

Ethics and regulation awareness are crucial components of skills training for executives, involving knowledge of the legal, ethical, and regulatory issues surrounding AI in healthcare. This includes understanding how AI should be addressed in contracts and ensuring compliance with relevant standards. Research and refinement skills include leading change management for AI implementation. Executives must be competent in managing transformative changes AI can bring to the organization. This involves effective communication, fostering acceptance among staff, and ensuring proper training and support.

The ability to monitor AI performance is vital for executives, requiring an understanding of relevant performance metrics and benchmarks to assess the effectiveness of AI implementation. This knowledge enables informed decision-making and ongoing optimization. Communication skills are integral for executives to effectively communicate the role of AI to stakeholders, including staff, patients, investors, and the community. Executives may also need to advocate for the adoption of AI at board meetings or other executive settings.

Staying updated with AI advancements is essential for executives, given the rapid pace of AI development. This involves keeping abreast of new tools, technologies, and regulations in the field, ensuring that executives remain well-informed leaders in the evolving landscape of healthcare AI.

Thus, the skills training for healthcare executives is comprehensive to a theoretical level and multifaceted that encompasses AI literacy, enablement, application, development, ethics and regulation, research and refinement, and an understanding of the broader societal impact of AI in healthcare. This training equips executives to navigate the dynamic landscape of AI implementation responsibly and effectively.



To summarize the details of skills training for the various roles mentioned above in the healthcare setting, Table 3 characterizes whether the training is limited to the Theory and/or Practical skills of each pillar. This is further detailed in Appendix B

Table 3: Healthcare Roles in LEADERS Framework inclusive of Frontline workers, Managers, and Business Leaders

Role	Literacy	Enablement	Application	Development	Ethics & Governance	Research	Society
Patient	√T				√T		
Front desk	√T				√T		
Nursing	√T				√T		
Clinician	√T				√T	√T	√T
Clinical Researcher	√T	√T			√T,P	√T,P	√T,P
Clinical Administrator	√T,P	√T	√T	√T	√T,P	√T,P	√T,P
Data Scientists	√T,P	√T,P	√T,P	√T,P	√T,P	√T,P	√T
Legal	√T				√T,P		√T
Human Resources	√T				√T,P		
Billing	√T				√T		
IT team	√T,P	√T,P	√T,P	√T,P	√T,P	√T,P	√T
Executives	√T	√T	√T	√T	√T,P	√P	√T,P

T – refers to Theory Training; P – refers to Practical Training. See the general LEADERS framework for additional details.

After determining the required extent of AI knowledge for an individual, institutions can make use of sample online courses provided in the Appendix. The list of courses aims to fill some of the gaps in AI education. Given the continuously evolving nature of this field, it is advisable to seek the most up-to-date courses relevant to the role.

## Call To Action

The urgency for AI skills in our workforce demands effective and robust **collaboration**. We are calling for a **powerful partnership between academia, industry, and business**. This partnership will create a dynamic learning culture, putting weight on a growth mindset, on the job hands-on training and seamless collaboration with industry. It will also help alleviate worker apprehension about the emergence of AI processes by optimizing workforce integration.

To bridge academia and industry, we propose consortia to prepare the workforce for future demands. We endorse the adoption of our **LEADERS framework** as a comprehensive tool for AI curriculum development, attuned to the diverse roles in the marketplace, from **frontline workers to managers to business leaders**. This focus on AI skilling and reskilling will ensure that the workforce is future-ready.

**Responsible AI** is an essential part of our call. We must weave academia and industry into a fabric of mutual benefits: that is, more funding and AI expertise for academia, more AI-skilled professionals for industry. The LEADERS framework, coupled with proprietary AI strategies, safeguards intellectual property while fostering innovation. Nonetheless, the surge in AI innovation necessitates establishing an **AI governing body** to advocate for ethics oversight and global standards enforcement.

In cutting a meaningful path towards beneficial AI utilization, it is crucial to consider consortia, academia-business partnerships, the LEADERS framework, and ethical AI regulations. They not only ensure responsible use of AI but also mitigate potential risks, ultimately paving the way for a progressive future in AI.

## References

1. Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton & Company.
2. Chui, M., Manyika, J., & Miremadi, M. (2016). *Where machines could replace humans—and where they can't (yet)*. McKinsey Quarterly.
3. Maslej, N., Fattorini, L., Brynjolfsson, E., Etchemendy, J., Ligett, K., Lyons, T., Manyika, J., Ngo, H., Niebles, J.C., Parli, V., Shoham, Y., Wald, R., Clark, J., & Perrault, R. (2023). *The AI Index 2023 Annual Report*. AI Index Steering Committee, Institute for Human-Centered AI. Stanford University.
4. Radford, A. et al. (2019). *Language Models are Unsupervised Multitask Learners*. OpenAI.
5. Brown, T.B. et al. (2020). *Language Models are Few-Shot Learners*. arXiv preprint.
6. Raffel, C., Shazeer, N., Roberts, A., Lee, K., Narang, S., Matena, M., ... & Liu, P. J. (2019). *Exploring the limits of transfer learning with a unified text-to-text transformer*. arXiv preprint arXiv:1910.10683.
7. Arntz, M., Gregory, T., & Zierahn, U. (2016). *The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis*. OECD Social, Employment and Migration Working Papers, No. 189, OECD Publishing, Paris.
8. Bessen, J. E. (2019). *AI and Jobs: The Role of Demand*. NBER Working Paper No. 24235.
9. Cath, C. (2018). *Governing artificial intelligence: ethical, legal and technical opportunities and challenges*. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 376(2133), 20180080.
10. Jobin, A., Ienca, M., & Vayena, E. (2019). *The global landscape of AI ethics guidelines*. *Nature Machine Intelligence*, 1(9), 389-399
11. Hagendorff, T. (2020). *The Ethics of AI Ethics: An Evaluation of Guidelines*. *Minds and Machines*, 30, 99–120.
12. Floridi, L., Cowls, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., ... & Schafer, B. (2018). *AI4People—an ethical framework for a good AI society: opportunities, risks, principles, and recommendations*. *Minds and Machines*, 28(4), 689-707.
13. Chui, M., Manyika, J., Miremadi, M., Henke, N., Sarrazin, H., Läubli, F., ... & Sanghvi, S. (2018). *Notes from the AI frontier: Insights from hundreds of use cases*. McKinsey Global Institute.
14. Vinuesa, R., Azizpour, H., Leite, I., Balaam, M., Dignum, V., Domisch, S., ... & Gustafsson, F. (2020). *The role of artificial intelligence in achieving the Sustainable Development Goals*. *Nature Communications*, 11(1), 1-10.
15. Mckinsey. (2020). *The McKinsey Global AI survey*.

16. Purdy, M., & Daugherty, P. (2017). What AI Can and Can't Do (Yet) for Your Business. MIT Sloan Management Review, 58, 48-55.
17. UNESCO. (2021). Global Education Coalition.
18. Seok, S. & DaCosta, B. (2021). Global Artificial Intelligence Curriculum Initiative – GACI Framework. UNESCO.
19. World Economic Forum, (2018). Towards a Reskilling Revolution: A Future of Jobs for All
20. Prentice, W. (2018). How CIOs Can Motivate Employees to Build a Digital Workplace. Gartner.
21. Manyika, J., Lund, S., Chui, M., Bughin, J., Woetzel, J., Batra, P., ... & Sanghvi, S. (2017). Jobs lost, jobs gained: What the future of work will mean for jobs, skills, and wages. McKinsey Global Institute.
22. NIST, (2018). Artificial Intelligence Standards.
23. Acemoglu, D., & Restrepo, P. (2019). Automation and New Tasks: The Implications of the Task Content of Technology for Labor Demand. NBER Working Paper No. 25684.
24. Aoun, J. E. (2017). Robot-Proof: Higher Education in the Age of AI. MIT Press.
25. Lohr, S. (2018). A.I. Will Transform the Economy. But How Much, and How Soon?. The New York Times.
26. Rands, S. (2018). Opening up pathways to industry 4.0 careers. Pearson.
27. Gartner, (2018). Survey Analysis: Practical Artificial Intelligence in the Enterprise.
28. Gartner, (2021). Emerging trends on the Gartner Hype Cycle for Artificial Intelligence.
29. Gartner, (2020). Top Strategic Technology Trends for 2021: People centricity, location independence and resilient delivery drive the AI trends in Gartner's top strategic predictions for 2021.
30. McKinsey & Company, (2017). Artificial Intelligence, Automation, and the Economy.
31. McKinsey & Company, (2018). Notes from the AI frontier: Applications and value of deep learning.
32. McKinsey & Company, (2019). How automation and AI are transforming organizations and work.
33. IBM Institute for Business Value. (2018). The enterprise guide to closing the skills gap: Strategies for building and maintaining a skilled workforce.
34. Forrester. (2020). Predictions 2021: Automation will reshape the workforce in 2021.
35. Forrester. (2018). Adapt To Automation Or Disappear: The Future of Jobs And Work.
36. Turing, A. M. (1950). Computing machinery and intelligence. Mind, 59(236), 433-460.
37. McCorduck, P. (2004). Machines who think: a personal inquiry into the history and prospects of artificial intelligence. Natick, MA: A.K. Peters.

37. Russell, S. J., & Norvig, P. (2016). *Artificial intelligence: a modern approach*. Malaysia; Pearson Education Limited,
38. EPOCH, 2022, CHART 2023 AI Index Report
39. Bostrom, N., & Yudkowsky, E. (2014). The ethics of artificial intelligence. In *The Cambridge handbook of artificial intelligence*, pp. 316-334. Cambridge University Press.
40. Chui, M., Manyika, J., & Miremadi, M. (2016). Where machines could replace humans—and where they can't (yet). *McKinsey Quarterly*.
41. Mauro, F., Kickmeier-Rust, M., & Albert, D. (2021). It's a (Bitter) Sweet Symphony: The Interplay of Artificial Intelligence, Digital Learning Analytics, and Soft Skills Gap in Higher Education. *Journal of Intelligence Studies in Business*, 11(1).
42. Loeb, S., & Bassok, D. (2014). Teaching quality and the question of preparation. *Education Next*, 14(1), 77-82.
43. Hager, G. D., & Murphy, R. R. (2018). The need for machine learning coursework in computer science and robotics curricula. *Science Robotics*, 3(23), eaau7980.
44. Bughin, J., Hazan, E., Lund, S., Dahlström, P., Wiesinger, A., & Subramaniam, A. (2017). *Skill Shift Automation and the Future of the Workforce*. McKinsey Global Institute, Discussion Paper.
45. Nguyen, A. (2015). The Effect of Curriculum Content on Student Outcomes. *Journal of Labor Economics*, 33(4), 885-927.
46. Bessen, J. E., Impink, S. M., Reichensperger, L., & Seamans, R. (2020). The effect of big data on workforce skills: evidence from online job postings. *Information Systems Research*, 31(3), 816-847.
47. Mawson, S. (2002). *Universities, Business and Knowledge Exchange*. Council for Industry and Higher Education, London.
48. Statista figure [study\\_id138971\\_insights-compass-2023-unleashing-artificial-intelligences-true-potential%20](#)
49. Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry-government relations. *Research Policy*, 29(2), 109-123.
50. Arbo, P., & Benneworth, P. (2007). Understanding the regional contribution of higher education institutions: A literature review. *OECD Education Working Papers*, No. 9, OECD Publishing.
51. Calo, R., & Rosenblat, A. (2017). The taking economy: Uber, information, and power. *Columbia Law Review*, 117, 1623.
52. Pasquale, F. (2020). *New Laws of Robotics: Defending Human Expertise in the Age of AI*. Belknap Press.
53. Collins, A., & Halverson, R. (2018). *Rethinking education in the age of technology: The digital revolution and schooling in America*. New York: Teachers College Press.

54. Aoun, J. E. (2017). *Robot-Proof: Higher Education in the Age of Artificial Intelligence*. MIT Press.
55. Charette, R. N. (2013). The shortage in applied mathematics talent. *Journal of Applied Mathematics*, 2013.
56. Weinberg, B. A., Owen-Smith, J., Rosen, R. F., Schwarz, L., Allen, B. M., Weiss, R. E., & Lane, J. (2014). Science funding and short-term economic activity. *Science*, 344(6179), 41-43.
57. McKinsey & Company. (2019). *Global AI Survey*. McKinsey & Company.
58. Statista. (2022). *Artificial intelligence (AI) market size/revenue comparisons 2016-2025*.
59. Kaplan, A., & Haenlein, M. (2019). Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, illustrations, and implications of artificial intelligence. *Business Horizons*, 62(1), 15-25.
60. Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education. Promise and implications for teaching and learning*.
61. Daugherty, P. R., & Wilson, H. J. (2018). *Human + machine: Reimagining work in the age of AI*. Harvard Business Press.
62. Elkin, L., Pullin, G., & Kind, M. (2019). Artificial Intelligence: The Importance of Trust and a Framework for Ethics. *Journal of Information, Communication and Ethics in Society*.
63. Whittlestone, J., Nyrop, R., Alexandrova, A., Dihal, K., & Cave, S. (2019). *Ethical and societal implications of algorithms, data, and artificial intelligence: a roadmap for research*. Nuffield Foundation.
64. Topol, E. (AI) surveillance ethics in health care. *Nat Med* 25, 367–368 (2019).
65. Luxton, D. D. (2016). Recommendations for the Ethical Use and Design of Artificial Intelligent Care Providers. *Artificial Intelligence in Medicine*, 95–100.
66. Caruana, Rich, et al. "Intelligible models for healthcare: Predicting pneumonia risk and hospital 30-day readmission." *Proceedings of the 21th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*. 2015.
67. Dignum, Virginia. *Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way*. Springer, 2019.
68. Floridi, Luciano, and Ai, Josh Cowls. "A Unified Framework of Five Principles for AI in Society." *Harvard Data Science Review* (2019)
69. Buczak, A. L., & Guven, E. (2016). A survey of data mining and machine learning methods for cybersecurity intrusion detection. *IEEE Communications Surveys & Tutorials*, 18(2), 1153-1176.
70. Lipton, Z. C. (2018). The mythos of model interpretability. *Queue*, 16(3), 31-57.
71. Provost, F., & Fawcett, T. (2013). *Data science for business: What you need to know about data mining and data-analytic thinking*. " O'Reilly Media, Inc."
72. Barocas, S., Hardt, M., & Narayanan, A. (2019). *Fairness and Machine Learning*.

73. Obermeyer, Z., Powers, B., Vogeli, C., & Mullainathan, S. (2019). Dissecting racial bias in an algorithm used to manage the health of populations. *Science*, 366(6464), 447-453.
74. Masood, Adnan, PhD, and Dawe, Heather, MSc. *Responsible AI in the Enterprise: Practical AI risk management for explainable, auditable, and safe models with hyperscalers and Azure OpenAI*. Packt Publishing, July 2023. Figure 1.2
75. Duke, Toju. *Building Responsible AI Algorithms: A Framework for Transparency, Fairness, Safety, Privacy, and Robustness*. Apress, 2023.
76. Wachter, S., Mittelstadt, B., & Floridi, L. (2017). Transparent, explainable, and accountable AI for robotics. *Science Robotics*, 2(6), eaan608.
77. Russell, S., Dewey, D., & Tegmark, M. (2015). Research Priorities for Robust and Beneficial Artificial Intelligence. *AI Magazine*, 36(4), 105-114.
78. Jobin, A., Ienca, M., & Vayena, E. (2019). The global landscape of AI ethics guidelines. *Nature Machine Intelligence*, 1(9), 389-399.
79. "FACT SHEET: Biden-Harris Administration Executive Order Directs DHS to Lead the Responsible Development of Artificial Intelligence." October 30, 2023. <https://www.dhs.gov/news/2023/10/30/fact-sheet-biden-harris-administration-executive-order-directs-dhs-lead-responsible>
80. Artificial Intelligence Risk Management Framework (AI RMF 1.0)." National Institute of Standards and Technology, January 2023, <https://doi.org/10.6028/NIST.AI.100-1>
81. Latonero, M. (2018). *Governing Artificial Intelligence: Upholding Human Rights & Dignity*. Data & Society.
82. Debray, Q., & Ellis, K. (2020). *Small and Medium-Sized Enterprises and the Use of AI: Building Capacity for Responsible Adoption*. SSRN.
83. Goodman, B., & Flaxman, S. (2020). European Union regulations on algorithmic decision-making and a "right to explanation". In *Data-Driven Prediction for Industrial Processes and Their Applications*. Springer, Singapore.
84. Perry, Brandon, and Risto Uuk. (2019) "AI Governance and the Policymaking Process: Key Considerations for Reducing AI Risk." *Big Data and Cognitive Computing*, vol. 3, no. 26, 2019, pp. 1, 8-12.
85. *Ethics Guidelines for Trustworthy AI*. European Commission - High-Level Expert Group on AI. (2019).
86. NSF invests in next generation of AI: (2020, August 26). National Science Foundation.
87. Hegarty, C. (2021, July 19). Google AI Residency Program 2021.
88. Belanger, D., Seuken, S., & Sra, S. (2019). Perspectives on the NeurIPS Experiment.
89. Group, Q. S. (2021, January 20). Colleges, universities partner with Google Cloud to launch AI, analytics programs. QS Quacquarelli Symonds.

90. Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, H., Ma, S., ... & Wang, Y. (2017). Artificial intelligence in healthcare: past, present and future. *Stroke and vascular neurology*, 2(4), 230-243.
91. Topol, E. J. (2019). High-performance medicine: the convergence of human and artificial intelligence. *Nature Medicine*, 25(1), 44-56.
92. Naylor, C. D. (2018). On the prospects for a (deep) learning health care system. *JAMA*, 320(11), 1099-1100.
93. Pesapane, F., Codari, M., & Sardanelli, F. (2018). Artificial intelligence in medical imaging: threat or opportunity? Radiologists again at the forefront of innovation in medicine. *European radiology experimental*, 2(1), 1-8.
94. Yu, K. H., & Kohane, I. (2018). Framing the challenges of artificial intelligence in medicine. *BMJ Quality & Safety*, 28(3), 238-241.
95. Kelly, C. J., Karthikesalingam, A., Suleyman, M., Corrado, G., & King, D. (2019). Key challenges for delivering clinical impact with artificial intelligence. *BMC medicine*, 17(1), 1-9.
96. Panch, T., Mattie, H., & Atun, R. (2019). Artificial intelligence and algorithmic bias: implications for health systems. *Journal of global health*, 9(2).
97. Blease, C., Kaptchuk, T. J., Bernstein, M. H., Mandl, K. D., Halamka, J. D., & DesRoches, C. M. (2020). Artificial intelligence and the future of primary care: exploratory qualitative study of UK general practitioners' views. *Journal of medical Internet research*, 21(3), e12802.
98. El Naqa, I. (2018). Understanding machine learning in radiation oncology: A guide for clinicians and researchers. *Medical physics*, 45(7), e676-e678.
99. Nagendran, M., Chen, Y., Lovejoy, C. A., Gordon, A. C., Komorowski, M., Harvey, H., ... & Sujan, M. (2020). Artificial Intelligence Versus Clinicians: Systematic Review of Design, Reporting Standards, and Claims of Deep Learning Studies. *BMJ*, 368.
100. Price, W. N., & Cohen, I. G. (2019). Privacy in the age of medical big data. *Nature medicine*, 25(1), 37-43.
101. Reddy, S., Allan, S., Coghlan, S., & Cooper, P. (2020). A governance model for the application of AI in health care. *Journal of the American Medical Informatics Association*, 27(3), 491-497.
102. Anderson, J. (2023). 289 Healthcare Organizations Were Impacted by Ransomware Attacks in 2022. *Becker's Hospital Review*. Retrieved January 4, 2023.
103. Diagnostic Errors. (2023). Patient Safety Network, Agency for Healthcare Research and Quality. Retrieved February 1, 2023.
104. Dzau, V. J., et al. (2017). Realizing the Full Potential of Precision Medicine in Health and Health Care. *Journal of the American Medical Association*, 318(16), 1561-1562. doi:10.1001/jama.2017.12293.
105. Remote 24-Hour Monitoring Shows Sizable Positive Effect on Cancer Patients. (2023). *BMJ*. Retrieved November 14, 2023.



106. Gao, Z. et al. (2021). A Novel Deep Learning Model for Automated Diagnosis of Breast Cancer Using Digital Breast Tomosynthesis Images. *Scientific Reports*, 11(1), p. 1979. doi:10.1038/s41598-021-81467-0.
107. "Mayo Clinic to Automate Patient Triage System." (2020) *HIT Consultant*, 2 July 2020

# Appendix

## A - Data Source Attribution – Key Sources



## B- Health care focused Roles

Role Based AI Skilling Areas – HealthCare Focus							
Role in Healthcare	Foundations of AI (Literacy)	Enabling AI Solutions (Enablement)	Strategic AI Applications (Interpretation)	AI Development (Technical Skills)	AI Ethics & Governance (Regulatory Knowledge)	Research, Oversight & Value Measurement (Analysis Skills)	Society (Communication)
Patient	Basic AI literacy and implications of AI in patient care including Bias	N/A	Understanding personal health predictions from AI systems & how bias can influence medical advice	N/A	Awareness of data privacy and rights in AI applications	N/A	Discussing AI-driven care and personal data use with providers. Ability to question and discuss potential AI biases
Front Desk Staff	AI literacy for administrative efficiency: - e.g. clustering for patient scheduling. Prioritization etc. Ability to understand Bias in AI systems	Proficiency in AI-enabled scheduling and EHR systems. Use of AI without discriminatory practices in scheduling and administration	Interpreting AI-driven administrative alerts. Identifying bias in AI-generated patient interactions and administrative tasks	N/A	Knowledge of patient data handling and privacy in administrative AI tools. Awareness of legal implications of biased AI systems in patient interaction	N/A	Develop expertise to be able to explain AI-based administrative processes to patients including any biases that may be involved
Nursing Staff	Understanding AI Models & outputs. Biases for patient monitoring & care	Operation of AI monitoring and alert systems equitably to ensure bias reduction	Interpreting AI-driven risk assessments and care suggestions with a hindsight on Bias	N/A	Understanding of ethical considerations of AI in patient care including Bias effects	Evaluating AI tool effectiveness in patient monitoring and reporting biases in AI	Communicating AI-based insights & bias to clinical teams and patients
Clinician	AI concepts including recognizing biases in diagnostic and treatment AI tools. causal deep learning and the role of statistical Modelling involving data	Clinical decision support tools and application Utilizing AI decision support tools critically, considering potential biases	Interpreting individualized treatment effects and outputs from AI models with an understanding of bias	Understanding of AI models for clinical use; Interpretable ML. Ability to adjust AI tools to mitigate biases in clinical settings	Ethical use of AI; legal aspects of AI in clinical practice. Understanding ethical responsibilities to counteract AI biases	Understanding of AI-driven clinical outcomes & AutoML models. Evaluating and mitigating biases in clinical AI applications	Understanding of expected outcomes and impact involving treatment plans involving AI with patients. Communicating the limitations of AI tools due to biases to patients
Clinical Researcher	In-depth knowledge of AI Models. Quantitative epistemology. Knowledge of how biases can affect AI in research	Use of data-centric AI in Auto ML Models. Open high dimensional data sets & Impact. Conducting unbiased data analysis using AI	Expertise in implementation of AI to specific use cases to correct Bias. Good understanding of Data Science	Developing predictive unbiased models; synthetic data generation for AI research. Overcoming Data Overload for Clear Application Insights	Understanding of ethical practices with AI and governance related to Healthcare. Adhering to ethical guidelines that include bias considerations	Quantitative analysis of research data using AI. Validating AI research tools. Ensuring that AI research accounts for and measures biases	Develop expertise on time-to-event analysis, treatment effect estimation, and treatment plans & being able to Sharing AI findings, biases in AI with the medical community

## Role Based AI Skilling Areas – HealthCare Focus

Role in Healthcare	Foundations of AI (Literacy)	Enabling AI Solutions (Enablement)	Strategic AI Applications (Interpretation)	AI Development (Technical Skills)	AI Ethics & Governance (Regulatory Knowledge)	Research, Oversight & Value Measurement (Analysis Skills)	Society (Communication)
Healthcare Administrator	Strategic implications of AI Bias in AI on healthcare management	Integrating AI solutions for operational management Implementing AI administrative tools with an awareness of bias	Strategic application and interpretation of AI analytics for healthcare administration including Bias	Understanding project management for AI initiatives Ensuring the development of AI tools without organizational biases	Knowledge of AI governance and policy implications Creating policies and procedures to address AI biases in administration	Measuring AI's impact on healthcare delivery; data-centric AI analysis and impact of biases on AI healthcare administration	Leading AI initiatives; discussions on AI biases in advocating for AI adoption
IT Professional	Technical understanding of AI systems; data-centric AI, biases in AI algorithms.	Implementation and management of healthcare AI systems (Machine Learning) Developing and managing AI systems with bias detection and correction	Interpreting AI system performance; clustering and understanding of causal inspired deep learning.	Skills in AI-related software development; machine learning frameworks Technical analysis of AI systems to identify and mitigate biases	Cybersecurity and Data Privacy, Quality, Governance in AI Applications Building AI systems that are resistant to biases	Supporting AI research infrastructure; Auto ML tools & AI solutions; Building creative models. Ensuring compliance with regulations that address AI biases	Communicating between technical teams and healthcare staff on AI & results. Explaining technical aspects of AI biases to non-technical staff
Policy maker	AI impact on healthcare policy; causal deep learning for public health. Understanding societal biases reflected in AI	Assessment of AI for regulatory compliance; interpretable ML for policy Shaping policies that ensure AI tools in healthcare are unbiased	Interpreting public health policies influenced by AI Interpreting legal and ethical aspects of AI biases	N/A	Developing AI governance frameworks; ethical policy for AI. Developing regulations that mandate bias considerations in AI	Policy development based on quantitative epistemology for AI impact assessment Policy assessment to ensure it addresses and measures AI biases	Communicating AI policy decisions, AI biases to the public and healthcare community
Legal Professional	AI legal implications; understanding individualized treatment effects & effects of treatment effects & effects of ML in a legal context.	AI contract and compliance management to also account for bias; understand interpretable ML in a legal context.	IP laws and legal aspects of AI in healthcare Legal analysis of the implications of biases in AI healthcare tools	N/A	Regulatory compliance; ethical considerations of AI in healthcare law. Knowledge of governing laws around AI Biases	Legal research in AI; quantitative epistemology for legal analysis Legal research to support cases involving AI biases	Educating stakeholders on AI and legal aspects of AI biases
HR Professional	AI in HR management; data-centric AI for recruitment. Recognizing biases in AI recruitment tools	Operation of AI HR tools; change management with AI implementation Implementing unbiased AI HR tools	Using AI for workforce analytics; interpreting AI for HR strategy	N/A	Ethical recruiting with AI; data privacy training in HR AI tools Training on ethical recruitment practices with AI	Data privacy and security in AI HR applications Analysis of HR data to detect and correct biases	Communicating AI policies to staff; managing AI-driven changes in the workforce. Discussing AI biases in HR practices
Billing Personnel	AI literacy in healthcare finance; Basics of AI in billing & Coding including awareness of Bias	Operation of AI financial tools with an eye on bias detection. Good understanding of financial modeling	Interpreting AI outputs for billing and finance accuracy Identifying and correcting biases in AI-driven billing and coding	N/A	Understanding privacy and security in AI financial tools. Knowledge of the financial impact of biases in AI billing systems	Data-centric AI in billing; accuracy and AI in financial predictions. Analyzing billing data to ensure unbiased AI application	Explaining AI billing processes to patients and stakeholders. Communicating about biases in AI billing systems to patients and insurers
Healthcare Executive	Strategic AI Integration; causal deep learning for executive insights Strategic planning to address biases in healthcare AI	Resource allocation for AI (ROI, Scalability etc) for strategic decision-making Resource allocation to develop unbiased AI systems	Interpreting broad areas to Pioneer AI treatments & next-gen clinical trials Executive decision-making with an understanding of biases in AI	Budgeting for AI initiatives; Planning for executive oversight on Data-Centric AI vs. Model based Oversight of unbiased AI development in healthcare	Legal and ethical strategy for AI Leading ethical governance to prevent biases in AI systems	Monitoring AI performance; data-centric AI for executive management Strategic oversight to ensure unbiased AI applications in healthcare	AI advocacy communicating AI strategies to stakeholders Advocacy and leadership communication about overcoming biases in AI

### C – Sample Courses table

AI Mastery: LEADERS Framework Sample Course Guide				
AI Fundamentals	<b>Introductory</b> – Conceptual Understanding (Theoretical Grounding) <a href="#">AI for Everyone – DeepLearning.AI</a> <a href="#">Why you need to know about artificial intelligence</a> (linkedin.com)	<b>Developmental</b> – Practical Exploration <a href="#">Artificial Intelligence Demystified</a> (online)   Oxford University Department for Continuing Education	<b>Strategic</b> – Advanced Insights <a href="#">AI For Business Specialization</a> [4 courses] (Penn)   Coursera	AI Literacy (L)
AI Enablers	<b>Inception</b> – AI Technology <a href="#">IBM AI Enterprise Workflow Specialization</a> [6 courses] (IBM)   Coursera <a href="#">Mathematics for Machine Learning and Data Science Specialization</a> (deeplearning.ai) <a href="#">Generative AI is a tool in service of humanity</a> (linkedin.com)	<b>Innovation</b> – AI Translators <a href="#">AI Product Management Specialization</a> [3 courses] (Duke University)   Coursera	<b>Mastery</b> – AI Strategic & Governance Roles <a href="#">AI Program for Decision Making with Wharton Online</a> (upenn.edu)	AI Enablement (E)
AI Application	<b>Conceptual</b> – Use Case Oriented Vision & Strategic Planning <a href="#">Digital Transformation Course – UX and AI</a>   Stanford Online <a href="#">How finding and sharing information online has evolved</a> (linkedin.com)	<b>Operational</b> – Ethical Leadership and Responsible Governance <a href="#">Artificial Intelligence: Implications for Business Strategy</a> (mit.edu)	<b>Pioneering</b> – Change Management and Organizational Transformation <a href="#">Artificial Intelligence Strategy</a>   Stanford Online	AI Application (A)
AI Development & Refinement	<b>Creation</b> – Experimental Learning <a href="#">Machine Learning Specialization</a> [3 courses] (Stanford)   Coursera	<b>Enhancement</b> – Collaborative Experience <a href="#">IBM Applied AI Professional Certificate</a>   Coursera	<b>Frontier</b> – Real World Application <a href="#">AI Strategy and Governance</a>   Coursera	AI Development (D) AI Research & Value Refinement
AI Accountability & Ethics	<b>Awareness</b> – Ethical Foundations & Principles <a href="#">Certificate in AI Ethics and Governance</a>   School of Computer Science and Engineering   NTU Singapore <a href="#">Generative AI and Ethics – the Urgency of Now</a> (linkedin.com)	<b>Guidance</b> – Accountability in Practice <a href="#">Data Science and Artificial Intelligence: Ethics, Governance, and Laws</a>   Harvard University	<b>Leadership</b> – Professional & Ethical Acumen <a href="#">Data Science Ethics</a>   Coursera <a href="#">Ethics in the Age of AI Specialization</a> [4 courses] (LearnQuest)   Coursera	AI Ethics (E)
AI Social Innovative Development	<b>Engagement</b> – Personal Growth <a href="#">Artificial Intelligence (AI) for Business Leaders</a>   Udacity	<b>Integration</b> – Collaborative Innovation <a href="#">AI for Good</a>   Coursera	<b>Visionary</b> – Reflective Practice <a href="#">Saïd Business School, University of Oxford   Oxford Artificial Intelligence Programme</a> (getsmarter.com)	AI Society (S)