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ORIGINAL ARTICLE

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Reimagining how we develop leaders for healthcare's evolving digital/data ecosystem: Implications for graduate programs in health administration

Dae Hyun Kim[*1], Christy Harris Lemak[2], Suzanne Boren[3]

[1] *Georgetown University School of Health, Washington, DC, United States*
[2] *University of Alabama at Birmingham, School of Health Professions, Birmingham, AL, United States*
[3] *University of Missouri, College of Health Sciences, Columbia, MO, United States*

ABSTRACT

Objective: The evolving healthcare landscape, driven by digital transformation and increasing reliance on emerging Artificial Intelligence-derived tools, calls for a reassessment of the competencies required for effective healthcare leadership. Traditional healthcare administration and informatics programs may no longer meet the current and future complexity of the contemporary healthcare system. This study examines how graduate healthcare administration programs could adapt to better equip future leaders with leadership, management, and technical skills.

Methods: The research draws on three sources of information that were analyzed by the authors: (1) a comparison of the National Center for Health Leadership Competency Model 3.0^{TM} and the American Medical Informatics Association Health Informatics Core Competencies; (2) analyses of opportunities to integrate health informatics in general and artificial intelligence (AI), in particular - into healthcare administration education competencies; and (3) insights from interviews with 55 C-suite executives from 33 U.S. nonprofit health systems.

Results: There are areas for integrating and synthesizing competencies from health care and informatics disciplines. In addition, AI may be integrated across a variety of competencies and learning activities. Future executives will require the ability to integrate technology and informatics knowledge and skills into management and leadership competencies, skills, and behaviors.

Conclusions: To prepare healthcare leaders for the digital age, educational programs must integrate informatics and AI-driven technologies into their curricula. This includes a focus on data analytics, financial training, regulatory knowledge, and change management. The study calls for a reimagined approach to healthcare education that ensures leaders are equipped to thrive in an increasingly data-driven and regulated environment.

Key Words: Leadership, Competencies, Healthcare executives, Digital technology, Alignment, Regulatory environment, Financial acumen, Change management, Artificial intelligence

1. INTRODUCTION

In the dynamic landscape of healthcare management, the roles and competencies required of C-suite executives have traditionally been compartmentalized into distinct categories: operations leaders (CEO, COO), financial leaders (CFO), strategy leaders (CSO), clinical leaders (CMO), human re-

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Correspondence: Dae Hyun Kim; Email: dk1146@georgetown.edu; Address: Georgetown University School of Health, 3700 Reservoir Rd NW, Washington, DC 20007, United States.

sources leaders (CHRO), and informatics leaders (CIO).[1] Historically, operations and strategy leaders have been educated through specialized health administration programs, such as those accredited by the Commission on Accreditation of Health Management Education (CAHME) while informatics leaders often emerge from backgrounds rich in technical experience or specialized through Master of Healthcare Informatics programs,[2] including those accredited by the Commission on Accreditation for Health Informatics and Information Management Education (CAHIIM). The rapid evolution of the healthcare environment, however, accelerated by the post-pandemic era, demands a reevaluation of (1) the knowledge and skills required for success and (2) the educational methods and approaches used in graduate programs.

The increasing significance of data analytics and informatics in healthcare decision-making underscores the necessity for healthcare administration programs to incorporate informatics-related courses and technical skills into their curriculum. In particular, Artificial Intelligence (AI) has rapidly emerged as having the potential to improve health and health care and yet, it also brings significant risk and ethical challenges. Integrating analytics and informatics into health administration is crucial for preparing future healthcare leaders to adeptly manage a data-driven healthcare system.[3] Conversely, healthcare informatics programs can no longer focus solely on technical and informatics skills. The changing healthcare landscape necessitates a broader educational scope that includes business strategy and leadership competencies.[4] The blending of these disciplines reflects the interconnected and rapidly evolving nature of modern healthcare systems where strategic decision-making, operations and informatics are inextricably linked.

The convergence of these disciplines and educational pathways is not just an academic exercise, but a practical necessity. The healthcare industry is experiencing a digital transformation, driven by advancements in technology and the increasing availability of "big data."[5] This transformation has created a need for leaders who are not only proficient in traditional management and leadership skills, but also possess a deep understanding of informatics and data analytics. Studies have shown that organizations led by executives with a blend of these skills are better positioned to leverage technology for improved patient outcomes and operational efficiency.[6] Moreover, the healthcare environment is becoming increasingly complex due to regulatory changes, evolving patient expectations, and the need for cost-effective care delivery. Leaders must navigate these complexities while fostering innovation and ensuring compliance with ever-changing regulations. This multifaceted challenge re-

quires a new breed of healthcare executives who are versatile and capable of integrating diverse skill sets into strategic vision.[7]

Given these trends, it is essential to re-shape the educational paradigms in healthcare administration. We are specifically focusing on graduate programs and suggesting that they must evolve to equip future leaders with the competencies needed to thrive in a digital healthcare ecosystem.[8] This includes not only traditional management skills, but also expertise in informatics, data analytics, and digital health technologies – including AI.[9] This paper aims to highlight the necessary competencies and perspectives that are required for leadership in a digitally-transforming healthcare environment and underscore the importance of reshaping educational frameworks to meet these demands.

2. METHODS

We rely on three sources of information and analytic techniques. First, we compared competencies in the National Center for Health Leadership (NCHL) Competency Model 3.0^{TM} and the American Medical Informatics Association (AMIA) Health Informatics Core Competencies. We identified and suggested ways to map the informatics competencies to the NCHL competencies. Next, we analyzed and suggested opportunities to integrate AI into the NCHL competencies. Finally, we analyzed interview transcripts from a comprehensive study on leadership aimed at accelerating digital transformation, involving 55 executives from 33 nonprofit health systems in the US. The executives were health system Chief Executive Officers (CEOs) and Chief Information Officers (CIOs) who were interviewed as part of a separate study.[10] The investigator's Institutional Review Board (IRB) approved the study design (IRB-300009793-002).

Interviews were uniformly conducted by a single research team member between October 2022 and April 2023. The structured interviews, facilitated through Zoom teleconferencing, were designed to last approximately 60 minutes. With consent from participants, these interviews were audio-recorded and transcribed, de-identified, and validated by the research team to ensure accuracy.

Data analysis was conducted using a deductive approach, initially identifying themes and subthemes. This process involved four coders, each analyzing transcripts by using NVivo software.[11] The analysis then evolved iteratively based on emerging themes. For accuracy and consistency, each transcript was coded by two coders, and the inter-rater reliability was assessed using the Kappa statistic, achieving an agreement rate of 92%. This was complemented by

continuous comparison for inter-rater agreement using the constant comparative method, enabling the identification of new patterns and sub-themes.

3. RESULTS

3.1 Competency model analyses

We began by comparing two competency models: NCHL and AMIA, with a focus on how informatics relates to each NCHL competency. This was done because our own experience in environments with both a CAHME and a CAHIIM accredited program led to a more nuanced, integrative view than often seen in traditional programs and in the industry.

As background, the NCHL Health Leadership Competency Model 3.0TM and the AMIA Health Informatics Core Competencies both outline key areas of competency development for healthcare professionals but with distinct focuses and applications. The NCHL Competency Model emphasizes leadership development within healthcare organizations. It is organized into seven domains, four of which are "action" domains (Execution, Relations, Transformation, and Boundary Spanning) that focus on practical leadership skills, and three "enabling" domains (Health System Awareness, Self-Awareness, and Values) that address personal and professional growth. This model supports leadership in various areas such as organizational transformation, collaboration, project management, and strategic orientation, specifically tailored to enhance healthcare leadership across organizational structures.

On the other hand, the AMIA Health Informatics Core Competencies are more focused on health informatics as an interdisciplinary field that combines health, information science, and technology to solve biomedical and healthcare problems. This model stresses foundational knowledge in areas such as clinical informatics, consumer health informatics, and population informatics. AMIA's core competencies are structured around using data, technology, and informatics to drive decision-making, problem-solving, and health outcomes, focusing on equipping professionals with technical expertise and an understanding of socio-technical systems and human behavior. While both models aim to enhance healthcare, the NCHL is leadership-focused, promoting high-level organizational and managerial competencies, whereas AMIA targets technical proficiency in health informatics, emphasizing the application of data and technology in healthcare delivery and decision-making.

These models were selected as examples only, as we recognize that programs in health administration and health informatics will often use different competency models. Table 1 provides a comprehensive overview of the intersection between health informatics and AI, demonstrating how both fields can be integrated to strengthen leadership competencies in healthcare. In general, the AMIA Core Competencies related to health informatics support the NCHL Leadership Competencies by providing the technological and data-driven tools needed to achieve the leadership goals set in the NCHL framework. Our analysis is presented in Table 1, column 2.

We next considered how AI could be included in both types of programs (HA and HI). Rather than considering a new, additional competency statement, we considered if and how AI might integrate in every competency. Our analysis is located in Table 1, column 3. For example, in the "Project Management" competency, health informatics is utilized by leveraging project management software specifically for health informatics projects, applying data analytics to monitor project progress, and using informatics solutions for resource management and risk mitigation. AI, on the other hand, enhances project management by optimizing resource allocation and scheduling, using real-time monitoring for project risks, and employing AI-driven tools to improve planning, execution, and evaluation processes. This pattern is repeated across all competencies, with health informatics typically focusing on data management, analysis, and communication tools, while AI is used to enhance predictive analytics, decision-making, and optimization across various aspects of healthcare leadership, such as organizational awareness, team leadership, and change management.

3.2 Qualitative interviews

This analysis focused on the competencies and perspectives that are viewed to be required in a digitally transforming healthcare environment. Eight first-order codes coalesced into four second-order themes. In this paper, we present our results stemmed from four main themes that emerged from our iterative analysis along with exemplary quotes from the health system leaders' interviews. The four main themes state that to effectively leverage technology and accelerate transformation, leaders must demonstrate these four traits:

1. Digitally/Tech Savvy Leaders. Leaders must have a strong knowledge of information technology, use data/analytics in decision making, and digital tools that can improve organizational performance.

2. Knowledgeable of the Regulatory Environment. CIOs and CEOs must understand regulations in general and the way it may impact IT investments, as well as how IT can be used to improve organizational reporting and effectiveness.

Table 1. Health informatics and artificial intelligence competences across the NCHL leadership competencies

NCHL Competency + Description	Health Informatics Competencies	AI Competencies
1. Community Collaboration Aligning organizational priorities with community needs and values.	• Use of informatics tools to gather and analyze community health data. • Developing population health management systems. • Utilizing health information exchanges (HIEs) to share data with community partners. • Engaging with community stakeholders using data-driven insights.	• Using AI to analyze community health data and identify needs. • Developing AI-driven population health management systems. • Using AI for predictive modeling to forecast community health trends. • Employing AI to support data-driven decision-making for community health initiatives.
2. Organizational Awareness Understanding formal and informal decision-making structures and power relationships in an organization.	• Mapping organizational data flow and information systems. • Analyzing internal data to identify key decision-makers. • Utilizing informatics to understand and predict the impact of organizational changes. • Leveraging data to understand stakeholder influences	• Using AI to map and analyze organizational structures and influence networks. • Leveraging AI to predict the impact of organizational changes on stakeholders. • Implementing AI-driven tools to understand internal data flow and decision-making patterns.
3. Relationship & Network Development Building and sustaining professional networks for shared goals.	• Using health informatics platforms to connect with professionals and stakeholders. • Maintaining electronic networks and communication channels. • Leveraging social media and professional networking sites for informatics-related collaborations. • Data sharing and collaborative tools for network development.	• Utilizing AI-powered networking tools to identify and connect with relevant professionals. • Using AI to analyze and optimize network interactions and collaborations. • Leveraging AI for maintaining and expanding professional networks through data-driven insights.
4. Accountability Holding people accountable to performance standards.	• Implementing performance tracking systems. • Using data analytics to monitor and report on performance. • Ensuring compliance through informatics tools. • Utilizing dashboards and reporting tools to maintain accountability.	• Implementing AI-driven performance tracking and reporting systems. • Using AI to monitor compliance and identify areas needing improvement. • Leveraging AI to ensure transparency and accountability through data analysis and reporting.
5. Achievement Orientation Surpassing standards of excellence through improvement and innovation.	• Applying data analytics to identify performance improvement opportunities. • Using benchmarking tools to compare with industry standards. • Implementing informatics solutions to achieve high performance. • Leveraging predictive analytics for continuous improvement.	• Applying AI to identify performance improvement opportunities. • Using AI for benchmarking and comparative analysis. • Leveraging AI-driven predictive analytics to set and achieve high-performance standards. • Utilizing AI to foster a culture of continuous improvement and innovation.
6. Analytical Thinking Understanding situations by breaking them down and analyzing parts systematically.	• Using data analytics tools for systematic problem-solving. • Applying statistical analysis to inform decision-making. • Utilizing informatics to conduct detailed data comparisons. • Leveraging health informatics for causal relationship identification.	• Using AI for detailed data analysis and problem-solving. • Leveraging machine learning to uncover patterns and insights. • Employing AI to make systematic comparisons and identify causal relationships. • Utilizing AI algorithms to enhance analytical thinking and decision-making processes.
7. Communication Skills 1 – Writing Using written communications to convey meaning and build understanding.	• Developing clear and concise health informatics documentation. • Writing reports and data analysis summaries. • Utilizing electronic communication tools effectively. • Ensuring accurate and accessible data presentation in written form.	• Utilizing AI tools for drafting and refining written communications. • Using AI-driven language processing to ensure clarity and precision. • Leveraging AI for automated report generation and documentation. • Employing AI to analyze and improve the effectiveness of written communication.
8. Communication Skills 2 – Speaking & Facilitating Using spoken communications to convey meaning and build understanding.	• Presenting data-driven insights and findings. • Facilitating discussions using health informatics data. • Using informatics tools to enhance presentations. • Communicating complex data in understandable terms.	• Leveraging AI-powered speech analytics to enhance verbal communication. • Using AI-driven tools to support effective facilitation and presentation. • Employing AI to provide real-time feedback and improvement suggestions for spoken communication. • Utilizing AI to ensure clarity and impact in verbal communications.
9. Initiative Taking proactive action to address current or future problems or opportunities.	• Implementing new informatics solutions to address emerging challenges. • Proactively using data to predict and prevent issues. • Leveraging informatics for innovative healthcare solutions. • Taking the lead on informatics projects and initiatives.	• Implementing AI solutions to proactively address emerging challenges. • Using AI to identify and capitalize on new opportunities. • Leveraging predictive analytics to foresee and mitigate potential issues. • Employing AI-driven tools to take initiative in problem-solving and innovation.
10. Performance Measurement Using statistical and financial metrics to set goals and measure performance.	• Utilizing informatics tools for performance tracking and reporting. • Applying evidence-based metrics to assess clinical and organizational performance. • Leveraging data analytics for continuous performance improvement. • Using dashboards and scorecards for performance measurement.	• Utilizing AI for advanced performance measurement and analytics. • Applying AI-driven predictive models to set realistic and ambitious performance goals. • Leveraging AI to continuously monitor and report on performance metrics. • Using AI tools to analyze and optimize clinical and organizational performance.

Table 1 continued.

NCHL Competency + Description	Health Informatics Competencies	AI Competencies
11. Process & Quality Improvement Analyzing and improving organizational processes for high reliability and continuous quality improvement.	• Implementing informatics solutions for process optimization. • Using data analytics to identify and address quality improvement areas. • Applying informatics tools to streamline workflows. • Leveraging health informatics for user-centered design and continuous improvement.	• Implementing AI-driven process optimization tools. • Using AI to identify inefficiencies and areas for quality improvement. • Leveraging machine learning algorithms to enhance process reliability. • Employing AI to design and implement continuous quality improvement initiatives.
12. Project Management Planning, executing, and overseeing large-scale projects with significant resources, scope, and impact.	• Utilizing project management software for health informatics projects. • Applying data analytics to monitor project progress. • Implementing informatics solutions to manage project resources. • Leveraging informatics for risk management and project evaluation.	• Utilizing AI-powered project management software. • Applying AI to optimize resource allocation and scheduling. • Leveraging AI for real-time project monitoring and risk management. • Using AI to enhance project planning, execution, and evaluation.
13. Collaboration Working cooperatively and inclusively with other individuals and/or teams they do not formally lead.	• Using collaborative informatics platforms for shared data access. • Implementing interoperability standards to facilitate data sharing across teams. • Using health informatics tools to enhance communication and teamwork.	• Using AI-driven collaboration platforms for enhanced teamwork. • Leveraging AI to facilitate communication and information sharing among team members. • Employing AI tools to support cooperative project management. • Utilizing AI to analyze team dynamics and improve collaboration outcomes.
14. Impact & Influence Persuading, convincing, influencing, or impressing others to support one's opinion or position.	• Utilizing data visualization tools to present compelling arguments. • Using health informatics data to support persuasive communications. • Leveraging predictive analytics to demonstrate potential impacts.	• Using AI-powered data visualization tools to create compelling presentations. • Leveraging AI to analyze stakeholder preferences and tailor messages accordingly. • Employing AI to predict and measure the impact of persuasive efforts. • Utilizing AI to support data-driven arguments and influence decision-making.
15. Interpersonal Understanding Understanding unspoken or partly expressed thoughts, feelings, and concerns of others, especially from diverse backgrounds.	• Analyzing patient and staff feedback using sentiment analysis tools. • Using informatics to identify trends and patterns in communication. • Implementing culturally sensitive informatics solutions to address diverse needs.	• Using AI-driven sentiment analysis to understand stakeholder emotions. • Leveraging natural language processing (NLP) to interpret unspoken concerns. • Employing AI to analyze communication patterns and enhance interpersonal understanding. • Utilizing AI tools to foster empathy and understanding across diverse groups.
16. Talent Development Building the organization's human capability and professionalism, including coaching and mentoring.	• Using informatics to identify skill gaps and training needs. • Implementing e-learning platforms for continuous professional development. • Leveraging data analytics to track and support employee performance and growth.	• Using AI for talent identification and recruitment. • Leveraging AI to personalize employee development plans. • Employing AI-driven platforms for coaching and mentoring. • Utilizing AI to track and support employee growth and performance.
17. Team Leadership Leading groups toward shared visions and goals, forming balanced teams, and holding members accountable.	• Utilizing project management software to coordinate team activities. • Implementing informatics tools for team communication and collaboration. • Using performance tracking systems to monitor and evaluate team progress.	• Using AI-powered tools to assess and build team capabilities. • Leveraging AI for real-time team performance monitoring. • Employing AI to enhance team communication and collaboration. • Utilizing AI to set and achieve shared goals effectively.
18. Change Leadership Energizing stakeholders and sustaining their commitment to changes in approaches, processes, and strategies.	• Using informatics to support change management initiatives. • Implementing data-driven strategies to demonstrate the benefits of change. • Leveraging health informatics tools to monitor and report on the progress of change initiatives.	• Using AI to predict the impact of change initiatives. • Leveraging AI-driven tools to manage and communicate change. • Employing AI to monitor stakeholder responses and adapt strategies. • Utilizing AI to sustain engagement and commitment to change.
19. Information Seeking Curiosity and desire to stay current with trends and developments, seeking precise information and best practices.	• Utilizing health informatics databases and journals to stay updated. • Implementing information retrieval systems for efficient data access. • Using analytics tools to explore new opportunities and trends in healthcare.	• Using AI for advanced data retrieval and information gathering. • Leveraging AI to stay updated with the latest industry trends. • Employing AI-driven tools to explore new research and best practices. • Utilizing AI to resolve information discrepancies and enhance knowledge acquisition.
20. Innovation Approaching work in new and breakthrough ways, developing creative solutions, or adapting previous solutions.	• Leveraging AI and machine learning for innovative healthcare solutions. • Using health informatics tools to develop and test new healthcare models. • Implementing pilot projects to explore and refine innovative ideas.	• Leveraging AI for innovative problem-solving. • Using machine learning to develop new healthcare models. • Employing AI-driven tools to test and refine creative solutions. • Utilizing AI to adapt and improve existing processes in novel ways.
21. Strategic Orientation Considering the business, demographic, political, and regulatory implications of decisions to improve organizational success and viability.	• Using predictive analytics to inform strategic planning. • Leveraging health informatics to assess the impact of regulatory changes. • Implementing data-driven strategies to align with long-term organizational goals.	• Using AI for strategic forecasting and scenario planning. • Leveraging AI to assess the impact of regulatory changes. • Employing AI-driven tools to develop long-term strategies. • Utilizing AI to align decisions with organizational goals and external factors.
22. Professional & Social Responsibility Demonstrating ethics, sound professional practices, social accountability, and community stewardship.	• Ensuring data privacy and security in all informatics practices. • Using health informatics to support community health initiatives. • Implementing transparent data reporting to maintain public trust.	• Ensuring ethical use of AI in all applications. • Using AI to support community health initiatives. • Leveraging AI to enhance transparency and accountability. • Employing AI to promote social responsibility and ethical practices.

Table 1 continued.

NCHL Competency + Description	Health Informatics Competencies	AI Competencies
23. Financial Skills Understanding financial information, preparing and managing budgets, and making sound long-term investment decisions.	• Using informatics tools for financial analysis and budgeting. • Implementing cost-benefit analysis using health informatics data. • Leveraging predictive analytics for long-term financial planning and investment decisions.	• Using AI for financial forecasting and budgeting. • Leveraging AI-driven tools for cost-benefit analysis. • Employing AI to optimize financial decision-making. • Utilizing predictive analytics to inform long-term investment strategies.
24. Human Resource Management Implementing staff development and management practices that comply with legal requirements and optimize workforce performance.	• Using HR informatics systems to manage employee data and performance. • Implementing e-learning and training platforms. • Leveraging analytics to assess and improve HR practices.	• Using AI for workforce planning and management. • Leveraging AI to streamline recruitment and onboarding processes. • Employing AI-driven tools for performance evaluation and development. • Utilizing AI to ensure compliance with HR regulations and best practices.
25. Information Technology Management Seeing the potential for technologies to support process and performance improvement, and actively seeking enhanced capabilities.	• Implementing and managing EHR systems. • Using health informatics to streamline administrative and clinical processes. • Continuously seeking and adopting new technological advancements to improve healthcare delivery.	• Implementing AI-driven IT solutions for process optimization. • Leveraging AI to enhance administrative and clinical technologies. • Employing AI to continuously seek and adopt new technological advancements. • Utilizing AI to support and drive IT management initiatives.
26. Self-Awareness Having an accurate view of one's own strengths and development needs and addressing them through self-directed learning.	• Using self-assessment tools to evaluate informatics competencies. • Engaging in continuous professional development through health informatics courses and certifications. • Leveraging reflective practices and feedback mechanisms to improve informatics skills.	• Using AI-driven self-assessment tools to evaluate personal strengths and weaknesses. • Leveraging AI for personalized feedback and development plans. • Employing AI to analyze behavioral patterns and their impact on others. • Utilizing AI to track progress and identify areas for continuous improvement.
27. Self-Confidence Belief in one's own capability to successfully accomplish work, even in challenging circumstances.	• Using data to support decision-making and build confidence. • Implementing informatics solutions with confidence in their positive impact. • Demonstrating competence in using advanced informatics tools and systems.	• Using AI to support data-driven decision-making, enhancing confidence in outcomes. • Leveraging predictive analytics to validate and support personal decisions. • Employing AI tools to simulate potential scenarios and build confidence in handling various situations. • Utilizing AI to gather evidence and reinforce confidence in one's capabilities and opinions.
28. Well-Being Establishing habits supporting well-being and creating a supportive work climate.	• Using health informatics to monitor and promote employee well-being. • Implementing wellness programs and tracking their effectiveness using informatics tools. • Leveraging informatics to model and promote healthy habits and practices within the organization.	• Using AI to monitor and promote personal health and wellness through wearables and health apps. • Leveraging AI-driven wellness programs to support employee health and well-being. • Employing AI tools to analyze and improve work-life balance. • Utilizing AI to provide personalized recommendations for healthy habits and practices. • Implementing AI to create a supportive and health-conscious work environment.

3. Financial Acumen in Health Information and Cyber Security. Executives described how CIOs and other technical leaders must be fluent in two areas related to financial acumen: Fiscal Management/Resource Allocation and Service Reimbursement. In addition, they stated CEOs need to be able to consider the financial implications of information technology investments and cyber security risks.

4. Change Management. Leaders described how their executives are engaged in complex, multi-faceted change management and all leaders must excel in the specific areas of Leading/Team Leadership and Visioning/Strategic Planning.

Representative quotes from each of the identified subthemes are presented in Table 2 to illustrate the key findings and provide deeper insights into necessary traits and skillsets future healthcare leaders need to possess in a digitally transforming ecosystem.

4. DISCUSSION

4.1 Implications for health administration programs

Based on the study's findings, both traditional and executive health administration programs should evolve to better equip future healthcare leaders with the competencies needed to thrive in a digital healthcare ecosystem. These programs should integrate more informatics-related courses and technical skills into their curriculum, such as training in data analytics tools like Tableau and understanding how to leverage big data for decision-making. Additionally, in-depth training on healthcare compliance, risk management, and policy interpretation will help students navigate the increasingly complex regulatory environment. Enhancing fiscal management, resource allocation, and service reimbursement education is also crucial, emphasizing strategic resource management to maximize patient care quality and organizational financial health.

For executive programs, advanced courses on health informatics, big data analytics, and digital health technologies should ensure executives are proficient in leveraging data for strategic decision-making. The curriculum should offer comprehensive modules on healthcare compliance, risk management, and the latest federal and state regulations, particularly focusing on telehealth and reimbursement policies. Advanced fiscal management, resource allocation, and understanding of healthcare reimbursement mechanisms will

be crucial for strategic financial planning and resource optimization. Leadership and change management training should be enhanced, focusing on strategic planning, visioning, and managing complex change initiatives. To support continuous professional development, executive health administration programs should introduce micro-credentials in emerging areas such as digital health and advanced data analytics, along with ongoing learning opportunities through short courses, workshops, and certifications. By incorporating these changes, health administration programs can ensure their graduates are well-prepared to meet the demands of a digitally transforming healthcare landscape.

Table 2. Representative quotes from interviews with 55 U.S. health system C-suite executives

Competency Area	Quote Regarding Skills to Accelerate Digital Transformation
Theme 1: Digitally/tech-savvy leaders	
Subtheme 1: Proficiency in Data-Driven Decision Making	*"Harnessing the power of data has been a game-changer for our organization. By leveraging advanced analytics, we are able to make informed decisions that enhance patient outcomes, streamline operations, and drvie strategic growth. Data-driven leadership is no longer optional-it is essential for navigating the complexities of today's healthcare landscape."* – CEO
Subtheme 2: Adaptation to Emerging Technologies	*"The pace of technological change in healthcare is relentless, and as leaders, we must noy only keep up but also anticipate what's next. Leader's role is to ensure that the organization is agile enough to integrate new technologies seamlessly, from AI to telehealth, and to guide the teams in utilizing these tools to transform care delivery and improve patient outcomes."* –CIO
Theme 2: Knowledgeable of the Regulatory Environment	
Subtheme 3: Regulation, Risk Management, Compliance	*"Especially in today's healthcare market, having that knowledge in compliance and risk management is not just beneficial, but absolutely a must for any CEO, CIO, or even any c-suite executive for that matter. This is because failure to adequately address risks can lead to significant operational, financial, and reputational damages. It's not only about meeting the standards, but also about preparing for potential challenges that could most certainly come up."* – CEO
Subtheme 4: Policy Interpretation & Implementation	"*I thought it was bad during COVID, but it has gotten worse post-pandemic. Both state and federal governments are continuously changing their guidelines when it comes to usage of telehealth and the reimbursement, so understanding these changes and integrating them into our systems is critical because we want to ensure that we continue to provide top-notch care while also safeguarding our organization from getting penalized or fined."* – CIO
Theme 3: Financial Acumen in Health Information and Cyber Security	
Subtheme 5: Fiscal Management & Resource Allocation	*"I really cannot emphasize the importance of fiscal management enough. And it's important to point out that efficient fiscal management isn't just about balancing budgets and understanding balance sheets. It is about strategically allocating resources to maximize patient care quality, while making sure that the financial health or our organization is strong. We work in a sector that is called healthcare where funding is intertwined with patient outcomes and now, technological advancements, and being able to fiscally manage your organization is so crucial for anyone to become a leader."* – CEO
Subtheme 6: Financial Acumen: Service	*"As a CIO, even though I am not a physician or a CFO, I recognize that knowledge of reimbursement mechanisms significantly influences our technological infrastructure and operational decisions. It is about aligning our IT strategies with reimbursement models to ensure we deliver value to our customers, which are our patients that come in to our facilities."* – CIO
Theme 4: Change Management	
Subtheme 7: Team Leadership	"*People need to understand that leadership is a skillset and I believe it is something that people can learn and need to be trained in. We need to train our leaders. That is why I spend a lot of time on training our informatics people in leadership and bringing our team together and sending them through different kind of leadership training exercises. If you want to be in c-suite, even as a CIO, you need to get training in leadership."* – CIO
Subtheme 8: Strategic Visioning	*"As a leader, you need to be able to strategically plan, envision what you are going to do, and execute. It's about foreseeing potential challenges and opportunities, and crafting a vision that not only responds to the present but also anticipate the future."* – CEO

4.2 Implications for health informatics programs

Both traditional and executive health informatics programs should also adapt to meet the evolving demands of the healthcare landscape, as indicated by the study's findings. To prepare informatics professionals for leadership roles, these programs should broaden their curriculum to include business strategy, organizational behavior, and leadership courses, ensuring that graduates possess both technical proficiency and essential business acumen. Training on healthcare finance and regulatory compliance is crucial, emphasizing the understanding of reimbursement mechanisms and the financial implications of IT decisions. Additionally, the curriculum should integrate advanced change management skills, focusing on leading digital transformation initiatives, managing resistance, and fostering a culture of innovation.

For executive programs, specialized training should further support continuous professional development. Executive health informatics programs should offer micro-credentials

in areas such as cybersecurity in healthcare, health IT project management, and advanced data governance. Tailored leadership development programs, including executive coaching, mentorship, and peer learning opportunities, should also be provided to address the unique challenges faced by senior informatics professionals. By incorporating these elements, both traditional and executive health informatics programs can equip students with the comprehensive skill sets needed to navigate the complexities of modern healthcare environments and drive technological advancements in their organizations.

4.3 Implications for incumbent health care leaders

Incumbent health are leaders must recognize that the integration of advanced technologies such as AI and data analytics is not merely a technical upgrade but a strategic shift that redefines organizational dynamics and decision-making processes. This means moving beyond traditional leadership competencies to develop a nuanced understanding of how these technologies can drive value across clinical, operational, and financial dimensions. Leaders should be prepared to engage with these technologies at a strategic level, ensuring that their organizations are not only adopting new tools but are also leveraging them to enhance patient outcomes, optimize resource allocation, and maintain regulatory compliance.

Moreover, as digital tools become increasingly embedded in healthcare operations, incumbent leaders must foster a culture of continuous learning and innovation within their organizations. This involves creating an environment where teams are encouraged to experiment with new approaches, learn from failures, and iterate on success. Leadership in this context extends beyond managing day-to-day operations; it requires a vision of how technology can be harnessed to meet future challenges and opportunities in healthcare. Leaders must also be vigilant about the ethical implications of emerging technologies, particularly in areas like data privacy and AI-driven decision-making ensuring that their organizations uphold the highest standards of patient care and trust. By prioritizing these strategic and cultural shifts, incumbent healthcare leaders can position their organizations to thrive in an increasingly complex and data-driven healthcare landscape.

As AI and digital technologies rapidly evolve in healthcare, ethical considerations must remain a priority. The accelerated pace of innovation means that patients will increasingly question the ethical foundations of their medical care. Issues such as patient privacy, data security, algorithmic bias, and transparency in AI-driven decision-making must be carefully managed to maintain public trust. Healthcare leaders must

ensure that AI applications align with ethical principles by upholding patient autonomy, ensuring informed consent, and promoting equitable access to care. Establishing clear ethical guidelines and governance structures will be essential to addressing these concerns as technology continues to advance.

5. CONCLUSIONS

The evolving healthcare landscape, marked by digital transformation and increasing complexity, necessitates a reevaluation of the competencies required for future health system leaders. This study highlights the essential skills and knowledge areas identified by analyzing both NCHL and AMIA competency models and qualitative interviews of healthcare executives, emphasizing the importance of integrating informatics, data analytics, and advanced leadership training into educational programs. Both traditional and executive health administration and informatics programs must adapt their curricula to include these critical areas, ensuring graduates are well-prepared to navigate and lead in a digitally driven healthcare environment. By incorporating comprehensive training in healthcare finance, regulatory compliance, and change management, these programs can produce versatile leaders capable of driving technological advancements and improving patient outcomes. The insights gained from this study underscore the need for continuous professional development and the inclusion of micro-credentials in emerging areas to keep pace with the rapidly changing healthcare sector.

While the focus of this research is on the training of future informatics and healthcare management leaders, AI and other emerging technologies will require a team of professionals working effectively together-including nurses, physicians, and the array of healthcare professionals. Future research will explore how AI may be instrumental in furthering true inter-professional collaboration and how all members of the care team will require technical and change management training in order to fully leverage AI and other rapidly emerging technologies.

Lessons for practice

• Graduate healthcare administration programs must integrate informatics and AI competencies into their curricula to equip future leaders for a digitally transforming healthcare ecosystem.

• Effective healthcare leaders will need to combine traditional management skills with proficiency in data analytics, regulatory compliance, and AI-driven tools to optimize organizational outcomes.

• Continuous adaptation and innovation in leadership training are essential for addressing the increasing complexity of

healthcare driven by technology and regulatory changes.

AUTHORS CONTRIBUTIONS

Conceptualization: Kim DH; Data curation: Lemak CH, Boren S; Formal analysis: Kim DH, Boren S; Investigation: Kim DH, Lemak CH, Boren S; Methodology: Kim DH, Lemak CH; Validation: Kim DH, Boren S; Visualization: Lemak CH, Boren S; Writing - original draft: Kim DH; Writing - review & editing: Kim DH, Lemak CH, Boren S.

CONFLICTS OF INTEREST DISCLOSURE

The authors declare they have no conflicts of interest.

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DATA AVAILABILITY STATEMENT

The data supporting the findings of this study will be made available upon reasonable request to the corresponding author. Access to the data may be granted based on the nature of the request and in compliance with relevant ethical and institutional guidelines.

DATA SHARING STATEMENT

No additional data are available.

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