FROST & SULLIVAN

The Artificial Intelligence Revolution Has Arrived in Healthcare

How it is Changing Everything from Care Provision to Operational Logistics

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ABSTRACT

Artificial intelligence (AI) in healthcare is being leveraged in many applications; most of the attention has been on futuristic clinical insights, but other uses of AI are relevant and may be more useful in the near term in operations to support managing organizations in an environment where efficiency is a competitive edge. We will examine how healthcare providers are using AI and discuss why planning for AI is necessary for the future.

ARTIFICIAL INTELLIGENCE

Already Substance Behind the Hype

In science fiction, artificial intelligence is a plot device to explore abstract concepts like consciousness and the consequences of unencumbered technological advancement. In the real world, artificial intelligence systems are often touted as a universal panacea to solving some of the most complex challenges in industries ranging from finance and retail, to fast food and, of course, healthcare.

Overwhelmed with hype, potential users, particularly those in the healthcare space, often lack a clear understanding of what these systems really do and how they can be leveraged within their organizations. What is the distinction between data analytics, machine learning and artificial intelligence? Are there artificial intelligence systems and applications that we can employ today, or are we better off waiting as these solutions undergo further refinement and validation? Beyond clinical decision support, are there other operational areas within our organization where artificial intelligence could be leveraged?

To answer all of these questions, it is probably best to set a strong fundamental understanding of what the artificial intelligence toolkit truly entails. Understanding the utility of those algorithms can help shed light on their benefits and limitations.

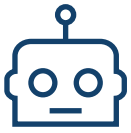
At a very basic level, artificial intelligence is broadly applied for use in applications or systems that can intuitively interpret complex information, and over time (leveraging machine learning) incorporate learning to optimize outputs. The science of artificial intelligence is ever expanding with new techniques and an associated lexicon. From a healthcare perspective there are a set of core tools that are utilized more often than others. Though distinct in function, these techniques can often be integrated or applied in concert to accomplish certain critical tasks.

AI and Analytics Are Not Synonymous.

While analytics involves systematic computations to gain insight and make decisions, artificial intelligence refers to the capability of a computer or machine to simulate human behavior. Many healthcare organizations utilize analytics to assess data and determine why something happened (descriptive analytics), and increasingly, to calculate what might happen (predictive analytics). Artificial Intelligence can be combined with analytics to support a variety of tasks, from routing a patient call to the right location to obtain the answer they seek, to giving insights on the optimal care pathway for an individual patient.

> “While analytics involves systematic computations to gain insight and make decisions, artificial intelligence refers to the capability of a computer or machine to simulate human behavior.”

Figure 1: The Artificial Intelligence Toolkit

TECHNIQUE	FUNCTIONALITY	WHY IT IS IMPORTANT TO HEALTHCARE
Computer Vision 	Systems entail high volume capture and real time analysis of digital images to support automated and decision support functions.	• Digital radiology • Environment monitoring • Telehealth consultations • Augmented reality • Virtual reality
Machine Learning 	These algorithms enable systems to take in new information, and apply those "learnings" to make changes to its analytical engine. The more information fed into the system, the better is it at guiding decisions.	• Data mining • Evaluating nuanced issues • Guiding diagnosis • Billing Coding • Error detection • Supply chain optimization • Cyber security
Natural Language Processing (NLP) 	NLP algorithms enable systems to read and understand information as inputted in everyday language via a variety of formats.	• Patient notes • Ordering • Guidance documents • Unstructured data • Data conversion • Document conversion • Query support • Text to speech • Speech to Text
Robotics 	The application of artificial intelligence to directives that can orchestrate various types of machinery.	• Surgical tools • Pharmacy automation • Patient positioners • Supply dispensing • Patient assistance • Training and support • Customer service

Source: Frost & Sullivan

AUGMENTING CLINICAL CARE

As healthcare systems continue to transition towards a model where quality of care, cost of care, and access to care are rewarded over volume of activities, providers are seeking newer methods and intelligent tools to support

- better and more efficient interactions with individuals
- identifying risk factors before catastrophic health events occur
- engaging in effective interventions that individuals will best respond to, based on their specific characteristics and circumstances
- improving clinical decision support tools in the hands of healthcare personnel at many levels

Care Delivery Optimization

Care networks are now looking beyond more basic metrics of clinical value when considering where to make technology investments, and proactively seek out solutions tailored to care delivery optimization. Deployment of intuitive expert systems can help achieve goals in

- mitigating unnecessary treatments/tests
- reducing errors in care delivery/diagnosis
- mitigating staff shortages and reducing errors resulting from staff fatigue
- improving efficiency in care delivery
- increasing access to services.

At the University of Pennsylvania School of Medicine, a machine learning algorithm mines patient health records to identify heart failure patients with a high risk of readmission. In London a group of hospitals known as the Royal Free London NHS Foundation Trust are using an AI-enabled app developed by Google DeepMind called Streams to predictively identify admitted patients who have a high risk of developing an acute kidney injury. Over time, the solution is expected to also be able to predict sepsis, liver dysfunction, and other risk factors leading to other types of organ failure.

Several efforts are underway to address aspects of the interoperability challenge, particularly data exchange among electronic health records (EHRs), using modern tools such as artificial intelligence-based platforms and systems that assist in automating most of clinical information generation, analysis, and sharing processes. Those systems have demonstrated widespread adaptability and scalability based on unique use case requirements.

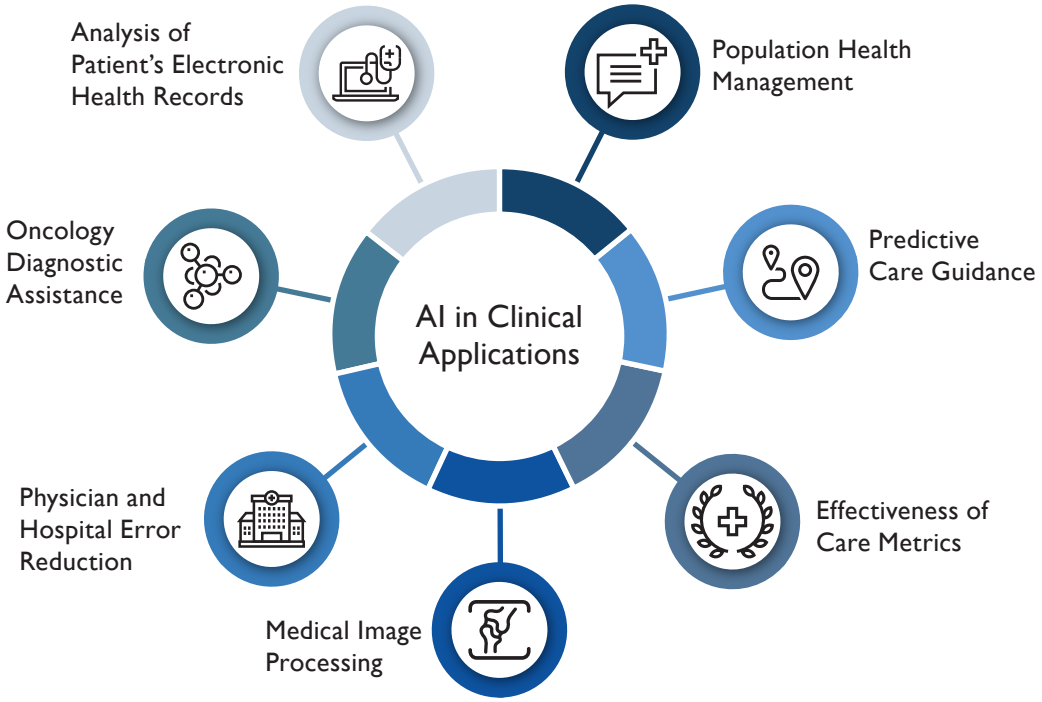
Reviewing and Interpreting Data

Beyond data interoperability, device interoperability is increasingly becoming a key area of focus for many healthcare facilities. With the rise of the internet of medical things, an ever expanding number of medical technologies offer connected functionalities. Those feature upgrades, unfortunately, come with capacity challenges for clinical care staff, who must now figure out how to effectively review and interpret the information available to them. Once in place, AI-supported systems can correlate data from multiple monitors and devices, and from there stratify patients into risk categories and provide components of predictive guidance regarding warning signs of a potential acute event.

A pilot at Partners HealthCare Brigham and Women's Hospital is looking to evaluate a continuous hospital to home monitoring system leveraging the Vital Connect VitalPatch wearable monitor and the physIQ Personalized Physiology Analytics platform to track patients who had been admitted with conditions ranging from COPD to

pneumonia. By analyzing monitoring data for key indicators, this insights-driven platform would allow the facility to proactively coordinate home visits for patients who otherwise would have potentially ended up back at the hospital for admission.

Figure 2: AI in Clinical Applications



Source: Frost & Sullivan

WORKFLOW OPTIMIZATION

Adapting from Other Industries

While there are a number of artificial intelligence system developers who are building dedicated healthcare solutions, the vast majority of developers have adapted approaches applied in other industries to healthcare. As adapted solutions, in some cases they can be limited when tackling more clinical use cases; however, in many respects other issues related to operational logistics are designed in a broad enough framework that they could be easily adapted for any industry.

Hospital efficiency directly and indirectly impacts the quality of healthcare provided to patients. By increasing a hospital's efficiency and workflow, care is delivered more effectively, while at the same time helping to reduce costs. For example, at Stanford's Lucile Packard Children's Hospital, its Program in AI-assisted Care is piloting an initiative that leverages sensors and computer vision technology to optimize hand hygiene protocols among staff. These types of environmental monitoring technologies provide hospitals real time information that can be used to optimize staff and asset management.

Inventory management within hospitals is an area that many consider to be in need of new ideas and technologies to improve efficiency. Overstocked supplies that expire can in aggregate for some facilities lead

to hundreds of thousands of dollars in wastage. Solutions that allow hospitals to better manage the products purchased from manufacturers, better understand the purchasing needs of the hospital, and save the time and decrease the workload burden of front line caregivers will ultimately lead to both decreased costs of healthcare and increased quality of patient care.

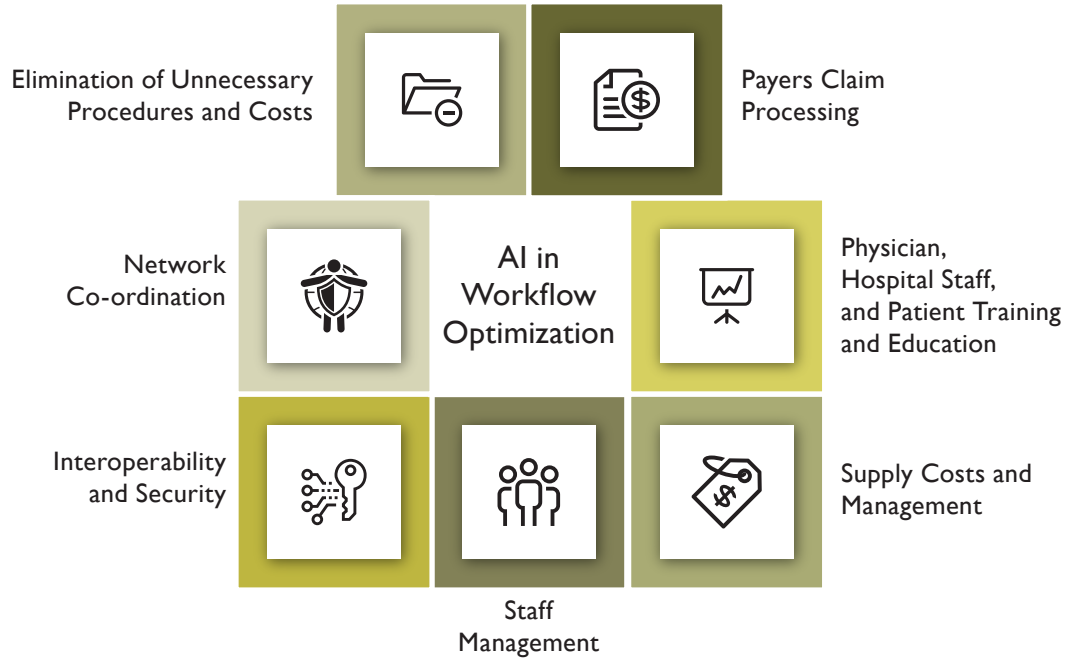
In many cases, supply management falls on front line caregivers to manually record usage and stock of supplies. Comparatively, in the retail world, large national chains have sophisticated automated tracking systems that can help identify throughput and adjust stocking to predicatively meet demand without manual adjustment.

With regards to capital equipment, artificial intelligence systems are exploring how to intuitively provide analytics related to equipment usage, location, down time, and servicing. Integrated solutions allow for more efficient sharing of equipment across multiple departments, and mitigate overspend on redundant technologies.

From a staff workflow point of view, systems can locate staff, track adherence to protocols, and through natural language processing, translate written and verbal notes into health record documentation almost instantly. CHRISTUS Health in Texas undertook a major initiative with health IT developer Nuance to leverage natural language processing in digitizing clinical documentation for radiologists and physicians. Whether via a dictation room, dictation station or smart phone, audio was securely captured and converted for review by a human transcriptionist. The cost and time savings of implementation has had a marked impact on their information management workflows.

In the near future, technologies could even be used to predict staff fatigue, and provide alerts to mitigate potential errors in care administration due to impairment.

Figure 3: AI in Workflow Optimization



Source: Frost & Sullivan

WELLBEING AND HEALTH

Patient Engagement is Key

In order to improve the customer experience, improve chronic condition management through more frequent interaction and to obtain better health outcomes at lower system cost, hospitals and hospital networks across the country are implementing better models for patient engagement. Massive investments in outreach efforts and web portals for patients have often witnessed impact that fell far below expectations for those organizations. The "build it and they will come" mentality has not helped with traction, as users have low participation rates and those that do engage often stop using the platform after a certain period of time. The most common reasons noted by users include complexity of the system and a perceived lack of relevancy.

As these programs depend on participation rates to effectively provide preventative wellness support, facilities are turning to artificial intelligence enabled solutions for engagement models that are more targeted and feel personalized to a given individual. Innovative apps merge elements of gamification, education, and social media interaction to create an environment that helps draw in patients and keeps them active on the platforms.

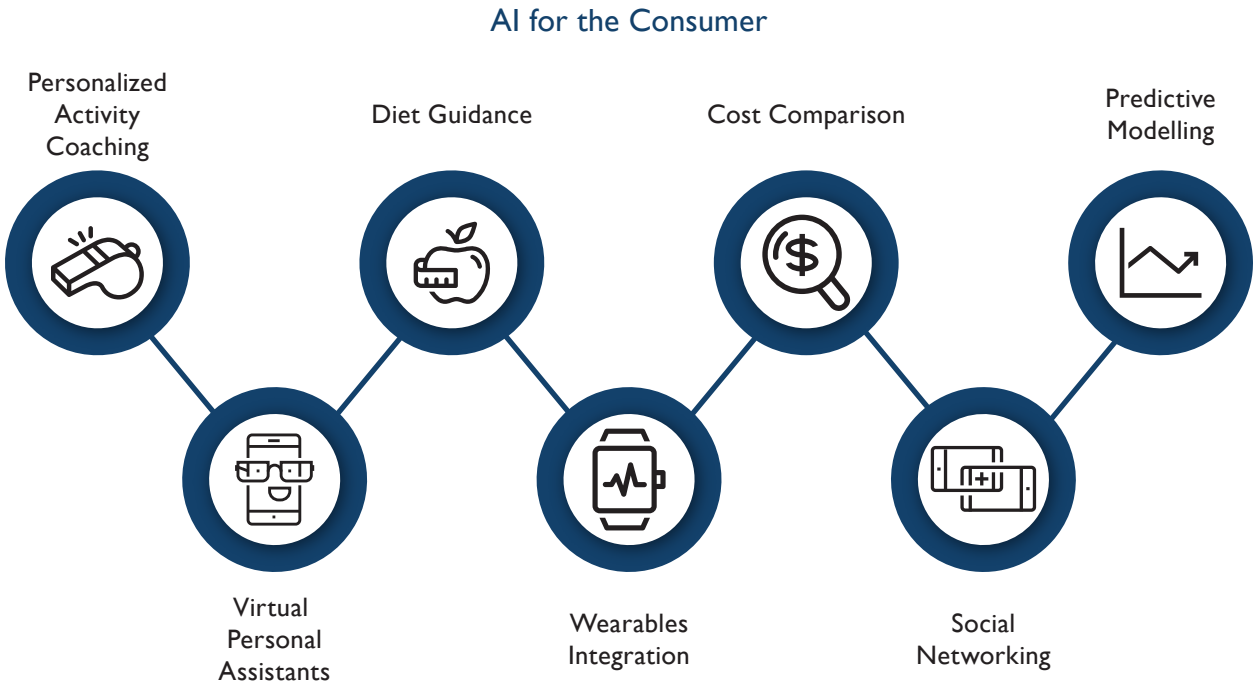
With the rise of digital assistants like Alexa (Amazon), Cortana (Microsoft), and Siri (Apple), consumers are getting increasingly comfortable with the concept of interacting with a digital avatar to ask questions, bark commands, and make purchases. In parallel, there are in development a number of artificial intelligence enabled chatbots tailored specifically for the healthcare environment. In the United Kingdom, their National Health Services (NHS) is working with Babylon Health to trial a chatbot triage service that would serve as the front line for their 111 national helpline. Particularly relied upon in after hours, the system can answer basic questions regarding symptoms, medication side effects, and provide general advice. Intuitively, the system also triages patients based on risk and need, with automated escalation ranging from a live telehealth consultation to scheduling an in-person check up at the hospital.

Personalization

Recognizing the importance of nutrition in maintaining a healthy lifestyle, many facilities have continued to invest resources in diet coaches and other forms of educational assistance to support healthier eating habits. For many patients, bridging the divide between understanding the importance of eating better and altering their behavior can be quite significant. New mobile health applications provide personalized nutrition advice to the user, based on their defined goals, chosen diet plan and identified dietary preferences and restrictions. With natural language processing support, a user can interact with the app in the form of chat messages, to input their queries and responses in sentences or phrases. Over time, machine learning enables the app to learn more about the user's diet choices, resulting in truly personalized recommendations. This personalization style puts the user in control, not a doctor or a nutrition expert.

A number of the technologies in development understand that an individual's health is determined by factors beyond just clinical factors. The ELLI.Q device from Intuition Robotics is positioned as an AI enabled platform that supports aging in place. The system integrates health monitoring with social interaction with family members and loved ones. Solutions like Virta Health individualize support to help type 2 diabetes sufferers manage their condition. Support from this solution combines biometric tracking, health coaching, as well as crafting personalized health and nutrition plans.

Figure 4: AI in Healthcare Consumer Applications



Source: Frost & Sullivan

IMPACT ON YOUR ORGANIZATION

Augment and Empower

Artificial intelligence sometimes is misperceived as a tool that could eliminate or reduce certain types of staff positions. In reality, artificial intelligence is not a replacement for personal interactions in healthcare, it is a tool for augmenting and empowering staff. While complex systems used in differential diagnosis might get all the attention, the reality is that the vast majority of systems will be used to automate repetitive and tedious tasks. An example of where AI can have an impact is in addressing administrative tasks that take up time, cause stress, and in general lead to inefficiency in the healthcare system overall. Other AI enabled tools adjust marketing campaigns, manage resource scheduling, and simulate audits.

Survival in the healthcare industry used to involve institutions maximizing medical coding and billing, and tightening budgets on staff and resources. Now, innovative hospitals are leveraging these artificial intelligence enabled tools to eliminate administrative waste, empower lower cost clinical personnel with knowledge, and unlock savings that can be reinvested in modernizing their services.

With retail care providers like Walmart, CVS, and Walgreens looking to significantly expand the types of services provided in their chains; they bring with them their expertise in applying automation, predictive analytics and operational efficiency to other aspects of their business. More traditional healthcare providers reluctant or unwilling to embrace technology solutions in a similar way could see significant attrition as these other entrants target certain types of primary care services.

In clinical care, while many organizations speak of becoming more data-driven, an overload of information is perceived as a liability that can overwhelm staff and prevent them from being able to make timely decisions. With the integration of machine learning and natural language processing, that "big data" liability now becomes an advantage that can help confirm course of care decisions with greater confidence. Mitigation of the administrative burden on staff alleviates a great deal of the extra stress that can exacerbate what is already a high pressure environment. Harnessing the power of these novel systems can enhance the effectiveness of how the staff provides care, and improve on the job satisfaction.

Healthier operating margins, happier staff, and improved care quality can go a long way in helping to strengthen a facility's external reputation in an era of transparency, where outcome and patient satisfaction scores will be used to compare institutions competing for the same patient populations.

A CALL TO ACTION—WHAT WORKS FOR US?

Find Your Greatest Challenges

In actuality, there isn't one right configuration or set of artificial intelligence tools that can work for all institutions. Figuring out where your organization can maximize benefit requires a thorough internal review that seeks to understand where the facility faces the greatest challenges in information management.

One of the often overlooked aspects of deployment of a suite of artificial intelligence enabled systems is that the effectiveness of the solution is completely reliant upon the quality of data it is fed. Garbage data in results in garbage results out. Therefore, along with decisions being made on what solution vendors to work with and the level of financial investment, institutions must consider process changes that adopt best practices in information management.

A second important aspect of leveraging the capabilities of AI solutions is to prepare the IT infrastructure that supports data capture, data management and data access across (and beyond) the provider organization. Additionally, healthcare providers need to make available adequate compute power for AI solutions to be deployed. In some cases, adequate infrastructure resources exist, but are not optimally organized, in other cases, additional infrastructure needs to be deployed. Vendor thought leaders with capabilities across data capture, compute, data management and access are best positioned to provide guidance in setting up infrastructure that will support healthcare provider needs today and tomorrow.

A common misconception for many institutions that were considering utility of these systems is that price premiums on software and investments in hardware upgrades would make them cost prohibitive in the short term. In reality, depending on the age and sophistication of systems in place, most facilities are able to implement programs with minimal upgrades to IT hardware. Moreover, with the proliferation of open source platforms and developers open to innovative pricing models tied to usage and performance; license costs are fairly accessible.

It should be acknowledged that what is recognized today as artificial intelligence is going to be vastly different from what will be viewed as "artificial intelligence" systems in the next decade. It is the nature of technology advancement. However, anticipation of what is coming next shouldn't prevent your organization from considering where existing tools and services can be deployed to deliver maximum effectiveness today.

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