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Chapter 10: Integrating advanced technologies into existing healthcare systems and workflows

10.1. Introduction

We are on the verge of a revolution of advanced technologies in healthcare. The potential for positive impact is vast and the barriers to entry are lower than at any time in the past. Today anyone can build software that can help diagnose or treat a patient. Technology detaches the very immediate elements of healthcare delivery: the physician who examines a patient face-to-face, obtains their history in an intimate questioning process, and devises a plan almost as though a partnership is made with the patient, can be augmented with a tool that analyzes hundreds of potential pathogenic causes of a cough or features of a chest radiograph. Such tools have the potential to reshape healthcare delivery; making it available where traditional access to medical expertise cannot. This ability to augment and enhance healthcare practice using advanced technologies is gradually migrating from academic medical centers to outpatient clinics, emergency departments, hospitals and even the home. It requires licensing of new products or modification of existing tools, which have until now relied solely on long-established ratio and clinical practice, with the ability to learn from actual practice and continuously improve as methods have begun to offer. This represents a further challenge to practitioners who need to both understand the technology tools available to them, and embrace advanced technologies enhancing rather than replacing their work (Alsalamah, 2012; Accenture, 2022; Deloitte, 2023).

This requires a multi-disciplinary partnership. No one professional group can address and solve the problems. Not every specialist who addresses a single problem needs to partner with early healthcare technology developers. But those who use any of the diverse applications will need to partner strategically and responsibly with the

researchers at the academic and commercial centers, and optimize the parameters and decision processes so as to ensure meaningful integration. This is essential to realizing the hoped-for grand vision of the transformative potential of advanced technology (Murdoch & Detsky, 2013; Frost & Sullivan, 2022; Zhai et al., 2023).

Fig 10.1: Integrating Advanced Technologies into Existing Healthcare Systems and Workflows

10.1.1. Background and significance

Health care organizations increasingly recognize the importance of utilizing advanced technologies, such as Artificial Intelligence tools, wearable sensors, computer-assisted workflow systems, and other telehealth capabilities, to address the chronic workforce challenges exacerbated during the pandemic. Doing so offers enormous potential to improve efficiency and enhance clinical decision-making, accelerate training, augment resident work, and reduce unplanned patient admissions. Despite the enormous investments made in advanced technologies, a significant percentage of digital transformation projects fail to even achieve their initial goals. These efforts do not realize their full potential and have only a limited positive impact on health care.

Digital technology seems to fit easily within medical ecosystems. However, these technologies require substantial changes in existing health care systems, including

workflows, patient interactions, care management pathways, and safety and risk policies. Most advanced technologies are introduced into existing health care systems without assessing ability to integrate or align with such systems. These capabilities are unlikely to be sliced away in a modular fashion. Like consolidation projects involving mergers and integrated system alliances, or large-scale change process projects addressing workforce shortages, efficient technological input into health care systems needs to find ways to integrate and align with the existing systems and processes.

Understanding the relationships between advanced technologies and existing health care systems should provide direction for several critical questions regarding enhanced technology utilization. What are the existing, ongoing, and changing organizational relationships that advanced technologies must synchronize? These synchronization pathways are the current care delivery system and organizational management pathways that advanced technologies must support. How should advanced technologies relate with their existing organizational logics? Organizational logics provide a structure for novel technologies that avoid unintended consequences, even as they may be changed or challenged by technological utilization.

10.2. Current State of Healthcare Systems

Although the healthcare industry is working on becoming paperless, the current workflow of healthcare systems remains cumbersome and primarily reliant on paper records. Patients move between many steps in the process of getting diagnosed, prescribed medicine or therapies, and requesting refills or renewals, and each step may still involve a paper interaction. Hospitals store Patient Health Information (PHI) in various locations. The hospital visit may involve many branches of the hospital, for example imaging, pathology, pharmacy, medical records, etc., and each of these areas stores PHI pertaining to the patient in a different manner and location. In addition, patients have to work with the hospital in order to get their records, and then manually copy or send this information to insurance companies, other hospitals, and their primary care physician (PCP) in order to coordinate their healthcare. Yet even with diligent attempts or encouragement from the patient, communications between hospitals and patients can result in delays, lack of records, or errors in records. The existing workflows are not webenabled, nor sufficiently digitized, to allow for timely and efficient data exchange. The evolution of web services and the Digital Online Economy demands a better patient experience in the healthcare processes and services.

Most hospital record systems have problems or limitations, including having a complicated setup, lack of existing standards for interoperability of systems between data layers through middleware, using incompatible formats for communication, and restricting patient access to their data or requiring significant effort. Few existing

systems allow for integration between medical information management and other tasks, at an enterprise level, as would be the case in a digitized online economy. As a result, the data remains fragmented, inconsistent, and not current. Information management of PHI in a manner that is integrated and useful to patients, hospitals, auxiliary areas within hospitals, and insurance companies, in a timely manner, is a challenge.

10.2.1. Overview of Existing Systems

The existing healthcare systems comprise a very heterogeneous set of software-only or hardware software systems designed to support healthcare workflows like Electronic Health Records, Laboratory Information Systems and Radiology Information Systems, but also a number of vendor-neutral systems for the distribution and visualization of healthcare imaging information, including those based on standards to enable the sharing and communication of imaging and other health information. There is also an increasing use of Third Party Apps and devices, designed based on clinical and imaging standards. These can connect to clinical and imaging cloud services, expertise optimization systems and other healthcare information, clinical or imaging management systems via standardized APIs. Some of these services also support the connection of devices and new tools employed in specialized use cases that require the integration of algorithms in clinical or operational workflows, such as models assessing Digital Pathology Information, Clinical Laboratory Systems, Clinical Decision Support for Images, or Radiology with Computer-Aided Detection/Diagnosis.

Imaging and Health Informatics make use of a number of computing environments and software and hardware capabilities, which range from clinical and imaging supercomputing cloud services to deeply embedded software running on specialized low and high performance devices. Healthcare systems consist of a party A sending a data request through a specific API, to a party B who registers this API with capabilities Z, whereby both systems (A and B) have undergone an interoperability validation certifying their capability to send and receive requests and data flows. The techniques, tools and platforms which these systems provide depend largely on the degree of digitization of the healthcare architecture at the hospital, regional, national and multinational levels.

10.2.2. Challenges in Current Workflows

Given the critical role of healthcare services, it is surprising that most advanced analytical technologies, particularly AI and ML, have progressed at a slow pace in the integration to existing healthcare workflows. In general, the majority of clinical use cases tend to rely on piecemeal implementations of relatively existing algorithms that often

deal with problems of high implications from clinical and operational perspectives – and, ironically, little from functional or economic perspective – that most decision makers in these organizations are frequently faced with. The main reasons for such slow-paced integration can be summarized as follows.

A first reason lies with the specialized character of healthcare analytics. Unlike existing enterprise system analytics that are mostly commodity problems involved when looking at the large combined volume of business data generated by the vast array of functional modules covering all operational areas, the data to be analyzed in healthcare are highly idiosyncratic. Each hospital is its own island and deals with usual operational challenges as part of its day-to-day workflow – making it difficult to crowdsource the applicable methods, and allowing for only limited information-led optimization compared to those systems where more empirical methods can be applied.

While the existing healthcare analytics do optimize the functions of care processes, little attention is paid to developing integrated solutions capable of addressing hospital performance as a whole. The specific analytics implementations are using micro-level performance indicators developed in isolation and on a very short time horizon, thus creating an aggregated quality picture that differs from the long-term macro-level approach that is the purpose of any care delivery optimization. This is one of the reasons for the still endemic practice of looking to cure clinical issues one at a time without adopting an integrated policy that is able to prevent their occurrence.

10.3. Advanced Technologies Overview

Advanced technology has entered the healthcare industry opening previously unimaginable improvements, increasing safety, reducing costs, and enabling providers to deliver more effective care. These benefits are the product of rapid advancements in advanced technologies, including Artificial Intelligence, Neural Networks, Natural Language Processing, virtual or augmented reality, robotics and automation, the Internet of Things, and telemedicine. Couple that with the recent pandemic with strong consumer and market demand, and these advanced technologies have become unprecedentedly ready for adoption and implementation. From offering tools that provide information, data, and workflows; to processes that provide advanced insights improving accuracy and efficiency; the benefits gained from integrating advanced technology within existing systems and processes are tangible. However, the advanced technology must be designed to seamlessly integrate into existing healthcare workflows and functionalities for the maximum opportunity to improve clinical care. Advanced technology must mitigate, not introduce, new risk and complexity within the healthcare environment.

The use of artificial intelligence methods is on the rise across all healthcare functions and technology landscape. AI in the form of Natural Language Processing is rapidly being integrated into the clinical transcription process, significantly accelerating the process of clinical documentation by clinicians, improving the accuracy of coding and billing processes within Revenue Cycle Management; while reviewing and providing insights for clinical decision support tools. Various AI-enabled back-end processing tools are being added to augment existing workflows. The degree of promise solutions offer and the rapid development and implementation of NLP capabilities presents the opportunity for AI in Core EHR functionalities to assume larger roles, offering smarter, simplified, faster solutions for everyone impacted - from clinicians to patients – integrated into the current EMR environments.

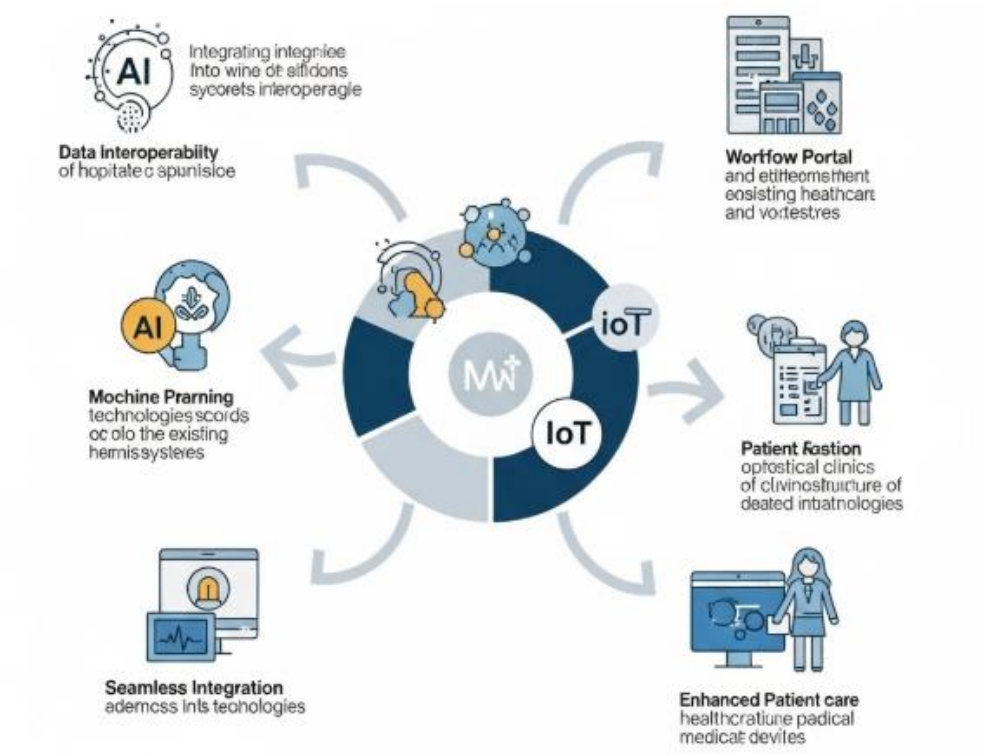

Fig 10.2: Advanced Technologies Overview

10.3.1. Artificial Intelligence in Healthcare

AI is the field of informatics that aims to transfer human capabilities of reasoning, learning, disagreement, perceptual and contextual understanding, sensory intelligence, or even taste rivalry, to the machine that is supposed to assist core human activities. Successful AI programs can indeed do so much better than human beings can that even

the most skilled of us would always prefer to delegate the activity to the machine instead of doing it ourselves. As a consequence, a large part of the above list of competences should not be looked for in an AI system, since it is often juxtaposed to the original human whole, but this is a good starting point to understand progress in AI for healthcare. AI tends to be rather domain-centered, so its relevant applications in the healthcare field are just a small fraction of its general potential existing applications. Moreover, many AI innovations applied to healthcare systems and workflows should not be considered disruptive; they could enhance existing diagnostic, implementing, or monitoring systems and capabilities. In this case the AI would simply use an available general knowledge model, which could be imbued with pre-existing healthcare competences and expertise, in order to improve on the quality of the decision-making support given by the medical professional. Referring to specific processes, the AI system would aim to be a decision-making buddy of the doctor, who has to give some explanation of the diagnosis or treatment decision being proposed to the patient, on the basis of his or her unique knowledge associations with the evolution of the phenomenon and the specific health conditions of the patient, which are essential to patient trust and compliance.

10.3.2. Telemedicine Solutions

While many advanced technologies have great potential, these technologies must be integrated with existing workflows and systems and often require practice redesign to achieve desired vision and increase the impact in practice. Telemedicine is one of such advanced technologies that can have great impact being used alongside other technologies. Some have noted that the pandemic was an unexpected laboratory testing the effectiveness of deployment of various telehealth solutions. It provided a great opportunity for rapid adaptation of telehealth technology in routine practice and testing its effectiveness across different services and conditions.

Telemedicine solutions allowed for the provision of remote clinical care during the pandemic, so the utilization of remote patient consultations increased dramatically. Providers and patients quickly adopted telemedicine as an alternative to in-person care delivery to keep the continuity of care. A virtual health environment enabled the accurate assessment of patients' conditions, risk factors, and needs during the pandemic in order to predict and reduce the burden on health services. Researchers organized consensus workshops to systematically assess the evidence on telehealth recommendations for chronic conditions in Primary Care. The workshops identified a set of telehealth recommendations and evidence for various medical disciplines for different health conditions which were valid during the pandemic based on a systematic review of recent guidelines. The telemedicine recommendations either allowed for drawing out a more comprehensive care plan or mandated a temporary or permanent reduction in physical

consultation frequency. These telehealth recommendations according to disciplines, health problems, and their levels of evidence and grades of the recommendation with the strategy of physiotherapies alongside other methods for patients and populations with chronic conditions were summarized.

10.4. Integration Strategies

Advanced technologies have the potential to radically transform existing healthcare systems and achieve improvements in both health outcomes and economic productivity. However, these potential gains may not be achieved automatically through the introduction of the technology. Existing healthcare systems are complex, adaptive systems characterized by tight coupling of interacting components, rich feedback loops, multiple stakeholders, distributed and hierarchical decision-making, and the potential for both intended and unintended consequences. Integrating advanced technologies into these existing healthcare systems requires thorough consideration of the organizational implications of the design, both from an individual workflow perspective and on the interacting components of the larger system. It also requires input and collaboration from relevant stakeholders throughout the entire integration process in order to maximize the technology's chances of success. In this chapter, we outline practical strategies for assessing integration requirements and developing buy-in from relevant healthcare stakeholders. We highlight several successful approaches from existing studies and initiatives that engage relevant stakeholder populations in the integration process. Integrating advanced technologies into existing healthcare systems requires careful thought and planning around how the technology will be embedded in organizational life, from individual workflow to organizational culture. The integration process ideally should be considered from the earliest stages of technology development, as the integration considerations are both interdisciplinary and highly customized to individual settings.

10.4.1. Assessing Organizational Readiness

Integrating advanced healthcare technologies into existing systems and workflows is complex, high-risk work. The risks associated with inadequate integration are particularly high in the healthcare domain. Unanticipated consequences, such as introducing new vulnerabilities that negatively impact patient safety, are well documented. Lack of effective integration may affect user engagement, affect agency willingness to enact required systemic or policy changes, and negatively impact user satisfaction and acceptance. It can also inadvertently introduce workload bias, where some users have a decreased workload while others become overburdened. This may, in

turn, create drag effects for agencies to successfully achieve their mission. At times the frustration associated with a poorly integrated advanced technology can lead to the advancement of myths about AI. In addition to impeding successful and effective implementation, these myths can adversely affect agencies and organizations that seek to leverage AI in the long run.

Before information system developers begin building or modifying existing technologies to accommodate new, advanced information processing or decision-support capabilities, they need to understand the existing operations environment into which the advanced technology will be integrated. This information will allow successful developers and evaluators to assess, in the context of their specific engagement with a participating user agency, its readiness for integration. Together with user participation in all stages of research, these assessments provide important input data into the integration effort. The agency must be willing to commit resources to the integration effort. Leadership may have to model positive attitudes toward user engagement with the advanced technology. Negative attitudes will need to be countered if the advanced technology is to be successfully implemented.

The knowledge and resources needed for an integration effort may not be concentrated within a single user agency, nor within a single information technology development company or consortium. Factors associated with agency integration readiness are not itemized with supporting data. The list is included to stimulate evaluation of the readiness of engagement participants, and to provoke discussion on factors that influence readiness.

10.4.2. Stakeholder Engagement

Stakeholder engagement refers to a range of activities designed to enable individuals impacted by the implementation of a system to contribute to the design, decision making, and evaluation processes undertaken by the implementers. Stakeholders may be classified as either internal or external. Internal stakeholders are individuals working within the organization, such as project leaders, governance teams, project management office staff, vendors, and system and network engineering teams. External stakeholders are individuals or entities outside the organization and include those who provide organizational support, such as regulatory agencies and advisory bodies; representatives from business partner organizations, such as payers; and teams working across similar or shared domains, including other healthcare service organizations or groups involved in public health initiatives. Stakeholder engagement is important for a number of reasons. First, input from engaged stakeholders is key to designing workflows that account for the use patterns, informational and reporting needs, and skillsets of the individuals involved in the use and associated processes of the system being

implemented. Second, integrating new systems into established - often complex and busy - organizational workflows can be very disruptive. Successes and failures during and immediately following implementation may trigger the temporary redeployment or removal of stakeholder activities from their normal functions. Stakeholder engagement during the planning and design phase may help to identify these potential delays or disruptions and inform contingency plans to mitigate their impact.

10.5. Case Studies

This chapter talks about specific examples of advanced technology integrations in existing healthcare systems. Smart hospitals leverage the latest innovations to bring evidence to care. Success increases stakeholder confidence and incentivizes other healthcare institutions to embrace innovation and change.

10.5.1. Successful Integrations in Hospitals

The Veterans Affairs Palo Alto Health Care System and the new Palo Alto Medical Foundation are examples of systems that embrace advanced technology integrations in their care delivery path. Both organizations represent within their system three of the most important areas for healthcare—ICT, Telehealth, and Robotics.

The Palo Alto Medical Foundation was the first outpatient surgery center in the United States to introduce robotic-assisted surgery for urology interventions. In the case of the Veterans Affairs Palo Alto Health Care System, Telehealth services provided by the team managed collaboration with the Department of Defense in the pre-surgical phase of the surgical path involving military personnel stationed in the Gulf Korea area and the recovery phase, where the patient after intervention is transferred to the Veterans Affairs Palo Alto Health Care System. All the collaboration was managed remotely utilizing Telehealth support. Furthermore, the Integration of Artificial Intelligence and Natural Language Processing by the 3D Printing department of the Bioengineering lab provided the surgical team with a 3D-printed integrated, specific model of the patient's aneurysm. Augmented Virtual Reality created by a collaboration of the 3D Imaging and Drug Development Branch departments was utilized during the phase of preparation of the surgery.

10.5.2. Telehealth Implementation Examples

Studies indicate the current U.S. healthcare crisis. There was a rise of telehealth by 48.2% from 2020 to 2021. As a consequence of the pandemic, regulatory barriers were

relaxed, resulting in the rapid expansion of telehealth services throughout the United States.

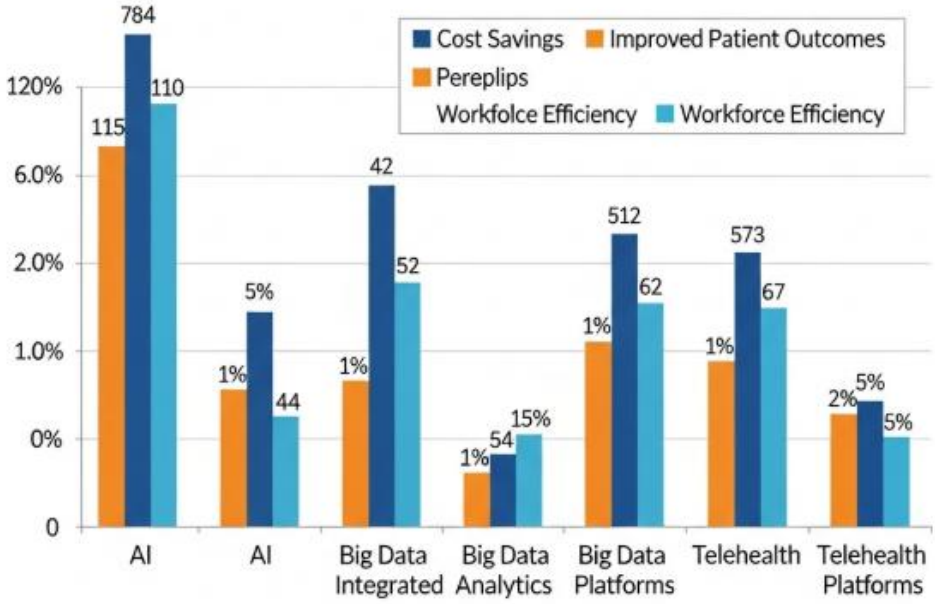

Fig : Existing Healthcare Systems and Workflows

10.5.1. Successful Integrations in Hospitals

Hospital systems are large, complex, bureaucratic organizations. The integration of technology into hospitals and healthcare systems is often difficult due to multi-level decision making, patchwork of policies and regulations, competing financial incentives, and variability of needs and characteristics of patients. These descriptions may discourage outside technologists from integrating advanced technologies into existing healthcare workflows and systems. Other technologists say that large, established healthcare systems tend to have an ideology that is somewhat at odds with emerging, innovative technologies. However, there is much incentive for hospitals to find ways to integrate technology efficiently within existing systems. For instance, hospital systems are sensitive to their reputations, both as centers of healthcare delivery and also as employers for existing and future staff. It is in hospitals' best interests to create welcoming, sanitary workspaces that protect their workers, rather than putting them at risk for getting COVID-19 or for complaining about how inefficient healthcare delivery with outdated workflows and design might interfere with their ability to provide care.

Examples of successful integrations of advanced technologies either into hospitals or into their affiliated small offices during the COVID-19 pandemic are given here. The

healthcare delivery systems feature, in general, low cost, high utility, limited risk, rapid training and easy use. Healthcare technologies examples include Airborne Infection Isolation Rooms, Negative pressure ambulatory clinic and tents allotted for people showing COVID-19 symptoms, Medical Robots, Hospital Soft Robotics, Automated COVID Pen, Telehealth Implementation and others.

10.5.2. Telehealth Implementation Examples

While creating a telehealth system is complex and may not always be manageable in every context, isolated telehealth implementation experiences offer useful resources, cautionary tales, and examples. Creating a digital bridge between existing healthcare systems and patients requires creativity, and successful implementations often blend the use of technologies such as video, texting, voice calls, shared data, and health monitoring, as well as the involvement of a range of workers.

In a public hospital that provides healthcare services to low-income populations in a California city, a mental health department offered psychiatric medication management services through video. Video visits required considerable effort to arrange and execute and were rarely attended; elsewise, the department relied on limited phone-only check-ins. As the mental health department did not devote sufficient resources to adapting external institutional policies, patients incurred considerable charges under their cellular plans when they dialed into the clinic for their appointments. Nevertheless, some patients communicated distress, discomfort, or concern about their mental health through dropping in to see their care manager; as the physical touchpoint using traditional care was inconveniently located, drop-ins occurred with minimal frequency. In addition, not all patients could access the technology; one patient relied on using text-to-speech software to overcome his barrier to system communication. Video calls were the primary medium of care, with appointments scheduled weekly.

10.6. Conclusion

A key pervasive tenet underlying the development, testing, and scaling of digital health technologies is that design for integration creates increased and prolonged likelihoods of real-world impact. Such impact is ideally situated within the work and workflows of healthcare systems and patient populations in which the technology is designed to act, allowing for timely testing and responsiveness to local context, work, and behaviors. Critical principles of design for integration are more established than a decade ago. Technologies that are less novel and specifically designed to create increased efficiencies and improved outcomes within healthcare settings with associated

integration with workflows, existing systems, and existing work streams are more likely to be embraced by healthcare organizations.

As the work of healthcare is increasingly facilitated by advanced computing technologies—primary care management algorithms, hospital patient flow simulation algorithms, resolution of complex medication management issues with multi-pharmacy software applications, GPS-driven routing of emergency medical service units deploying to overdoses of illicit opiates, and use of AI deep-learned imaging classifier models in the supervision of work of human diagnostic radiologists—the ethic of integrating human and machine work is even more urgent. As novel AI predictive and optimization algorithms are proposed to relieve the burden of cognitive work and decision fatigue from already burned-out healthcare workforces and to augment existing diagnostic pathways, the need for strategic design for integration within existing healthcare workflows is paramount. With the deployment of advanced technologies to execute, facilitate, or augment work also comes the inherent responsibility to develop computer models promoting normalization and equity in outcomes promotion within teams of humans, teams of humans and machines, and then teams of machines.

10.6.1. Future Trends

The consequences of changing health-seeking patient behavior, shifting demographics, and dwindling healthcare workforces are already being felt across high-income countries and will likely become more pronounced as economic pressures rise in higher debt countries. The integration of advanced technologies is essential to enhancing existing healthcare systems while also ensuring that these systems remain economically and clinically sustainable in the future. Historically, the introduction of advanced technologies in medicine has been driven largely by advances made in diagnostics, therapeutics, and treatments; when carried out effectively, it has been viewed as necessary to ensure that healthcare delivery keeps pace with advances made in these areas. It has generally been anticipated that the use of advanced technologies would ensure that the costs attached to providing advanced treatment are mitigated by the increases to the efficiency with which healthcare providers work. But just as patients have become more involved in decisions surrounding treatment, so too has there been mounting pressure on providers to ensure that their work has both clinical and a therapeutic benefit. For these reasons, successful installations of advanced technologies in the healthcare space must consider the manner and complexity of the healthcare system and the workflows that currently underpin the space.

The demand for behavioral and physical therapeutic solutions that embrace advanced technologies is only anticipated to grow in the coming years. Increased efforts to track and quantify relevant user behavior patterns, treatment methodologies, and health and

wellbeing adherence leads naturally into consideration of advanced technology-enabled services and products by clinicians in their efforts to address emerging mental and behavioral conditions. Devices that bridge that gap between the natural divide of decidedly unnatural treatment delivery and the lived experience of patients are anticipated to become clinically preferable. Practical adoption-focused integration of advanced technologies, at the user and system levels, will lead the charge for improved clinical healthcare pathways for consumers and enhanced healthcare outcomes for all stakeholders in the future.

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