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Chapter 1: Redefining modern healthcare by integrating artificial intelligence into patient-centered care systems

1.1. Introduction

The transformation of our world through technology is continual, challenging society in countless ways and offering extraordinary benefits. With modern healthcare, like any other field, the possibilities of new intelligent solutions co-evolve with the complexity of choices to be made. Artificial intelligence (AI) in all its forms and applications, in interaction with robotics or embedded in other technologies, is at the forefront of the technical innovations that offer new options for improved care and quality of life or that, eventually, will raise concerns not only about privacy (Wang et al., 2019; Brown & Elenitoba-Johnson, 2020; Shaik et al., 2023). Others might introduce more subtle interferences in the decision process between physicians and patients, than the ones we know today. Modern health systems, based to a large extent on the care of acute cases (whether they relate to diseases or to injuries), are nevertheless part of an industrial era paradigm, and it is more and more recognized that they have to be profoundly changed, driven mainly by the needs of an aging population, by the increase in chronic diseases and by changing expectations about care quality.

The integration of AI technologies is seen as a key to creating new patient-centered care systems. AI systems can reason, learn, predict, and help to make decisions, based on structured, and increasingly unstructured, data. They can interact in natural language, with vision, and with hearing. Health professionals are naturally interested in tools of such a nature to help them provide a better quality of care. Patient expectations, on the other hand, not surprisingly, favor care organizations that are more responsive to their individual needs and that provide a more personalized or at least sympathetic attention.

However, the pathways to designing and introducing such innovative systems are numerous, some being still unknown. Artificial Intelligence, in many of its forms and applications, will likely have a fundamental role. Automated reasoning engines can guide subtle modifications in treatment plans and help in the choice of care paths that better fit specific personal or clinical constraints of the patient. Generally, altogether with robotics, AI technologies offer a plethora of opportunities to optimize diagnosis, treatment and follow-up of individual cases and pave the way to the design of predictive health systems.

Fig 1.1: Artificial Intelligence-Based, Patient-Centric Healthcare System

1.1.1. Background and Significance

To date, artificial intelligence (AI) has been mostly studied confined within the patient-Centered Care (PCC) paradigm, the most referred model of PCC according to bibliographic reconnaissance. While PCC has been decanted as the modern holistic model of healthcare embracing both biological and psychosocial dimensions of health, rapid development of AI potentially enables a more extensive and complex role of AI within healthcare. In other words, the current PCC model might become redefined from

manual-supported patient-driven healthcare to largely AI-supported AI-directed and predictive healthcare paradigm changes. There has been no thorough study for the intersection of AI within PCC as well as its paradigm changes. Given the converging point, it necessitates re-evaluation of the PCC paradigm within the interest of the healthcare community, particularly scholars within the health informatics domain.

AI has powerfully influenced the healthcare profession, particularly in interpretations of images, diagnosis, patient care, and in offering pattern and data recognition. While AI has gained popularity globally, the commitment to its theory of changes has wavered over time. Therefore, a focused article on the utilization of AI in healthcare is very timely. Its comparative changes in the PCC model are documented with the goal to emulate the changing disciplinary trend. Given the dramatic increase in AI articles non-related to the PCC model, the analysis.

1.2. Understanding Patient-Centered Care

There are common clinical scenarios when new healthcare innovations are used to yield patients better outcomes but are met with resistance by the physicians using them. Because such innovations improve the average but not the individual patient outcome, the novelty of the technological interventions established only hinders patient care due to the already high narrative complexity of healthcare settings. On the contrary, what becomes highlighted is the patient-centered-ness of care – a narrative of care that is restricted to the medical staff and denying the patient's agency, preferences, and values.

What's been a more recent concern is the adaption of these patient-centered systems to AI and health technology. The fear is that using AI and predictive tools in patient-centered care systems would transform medicine into a sequence of technical checks and omit the profiling complexity and venture empathy produced by the doctor-patient relation. However, adopting a pluralistic discipline-centered view of care and accepting that patient-centered care systems are a tangle of branch-specific narrative strategies, such a fear seems to be a mere linguistic obfuscation – the fear that the doctor-AI dialog may lack interpretability or be mistaken by the patient as medical gaslighting.

1.2.1. Definition and Principles

User-centered artificial intelligence tools are being integrated into the daily life of modern societies and reshaping how individuals live and interact with their environment (Brown & Elenitoba-Johnson, 2020; Shaik et al., 2023). Patients are beginning to accept artificial intelligence-enabled systems for their healthcare. The slow but steady infiltration of these new digital skill sets into the most precise of healer hands is radically

redefining the antiquated Western medicine model. With cognitive artificial intelligence algorithms at their disposal, physicians will be able to accelerate the understanding of pathological processes and improve the choice of treatment by accurately predicting its outcomes. For patients, receiving machine-augmented care means feeling the impact of evidence-based sciences expressing state-of-the-art medical knowledge that would be impossible to anticipate from a human interlocutor. This different paradigm of medicine disillusions the illusion of Western physicians as 'all-knowing' demi-gods sufficiently competent to predict the outcome of the patient's sickness. Clinical practice will thus be restructured around the principle of evidence-based science parsing the specific outcome of the disease trajectory instantaneously apprehensive from patient trajectories and transparent decisions rules. A linear causality chain will condition intervention rationales on the unequivocally identified proximal future of the patient's disease (inferred from early patient trajectories) and on the next best intervention.

1.2.2. Importance in Modern Healthcare

The role of artificial intelligence (AI) in accelerating the advancement of medical research is undeniable. AI's contribution to medical research spans diverse fields, from supporting researchers in sifting through genomic sequences to identify disease-predisposing mutations, to drug discovery, where it expeditiously sifts through vast chemical spaces to identify therapeutically promising candidates. In the past decade, advancements in transformative learning frameworks have led to the democratization of AI technology. Healthcare positioning patient values and preferences front and center are identified as decisive for any given clinical scenario. It is paramount that the role of human judgment not be disregarded. Patient treatment preferences are as multifaceted and contextual as the healthcare professionals entrusted with upholding these principles. Furthermore, the treatment planning process should consider patient values, priorities, and the dynamics of the community a given patient resides in. Patient-centered care methodologies focus on enhancing the care received by patients, ensuring their needs and values are considered while making evidence-based medical decisions.

In addition to the current challenges facing patients, healthcare professionals, and policy-makers, innovative AI-driven solutions have the potential to redefine modern patient-centered care systems. AI-driven solutions in the context of modern patient-centered care systems should point out the patient's pre-suggested treatment options. Extending such a platform by providing accessible tools for organizing patient opinion via the patient dashboard would allow healthcare professionals to quickly identify patient values and treatment preferences. While it is paramount to consider a patient's priorities, diagnosis, and the provisions of a given health system, equal weight should be placed on patient preferences. It can assist healthcare professionals in crafting therapeutic treatment plans

that align the patient values and clinical constraints. The clinical performance of such treatment plans can then be evaluated holistically, considering patient-reported outcomes alongside clinical ones. Lastly, the incorporation of longitudinal data supports the monitoring of a patient's response to treatment plans over time.

1.3. Artificial Intelligence in Healthcare

2015 was a tremendous year for the integration of artificial intelligence into healthcare. Google famously stunned the world in March with its AI program for the automatic diagnosis of diabetic retinopathy. This ‘deep learning’ algorithm had been trained on a database of around 130,000 retinal images and demonstrated diagnostic accuracy on a par with a panel of 6 local ophthalmologists. But Google is by no means the only player in this space. Just a few months earlier, IBM had launched a similar initiative to develop an incredibly sophisticated cancer diagnostication and treatment recommendation engine. And the accumulating success stories of AI integration don’t even end there. Even just for neurology, which is the sub-speciality that traditionally has the fewest R&D expeditions and is therefore usually the slowest to adopt any new diagnostic or therapeutic practices, there are already many feasible AI-supported applications on offer. The ADAP Technologies APK030 INSOMNIA system uses passive sensory monitoring to help diagnose and manage the sleep disturbance patterns associated with the most common sleep disorders, including insomnia, restless leg syndrome, and sleep apnoea. Meanwhile, the incipio GmbH delayChecker is a software package using both interactive gut brain axis analysis and artificial neuronal networks to help diagnose and treat young people suffering from non-bacterial forms of irritable bowel syndrome. And more recently, the Neurotechnology NT-300 brain-computer neural interface has been launched, which is the first of its kind system specifically designed to allow paralysis sufferers with congenital motor function communication deficits to still be productive members of society by being able to post content to the Internet just with their thoughts. None of these products have transformed patient care to the extent that antibiotics, MRI imaging or thrombolysis have, but nor are they experimental curiosities gathering dust on the academic research shelves. Instead, they are emblematic of a genuine alternative healthcare delivery future that is rapidly approaching.Health informatics, such as AI, has become an evolution in digital healthcare services and has had a huge impact on remote patient health tracking. AI and ML have been shown to be relevant in reducing the total costs of remote patient health care. AI provides precise solutions and accurate diagnosis for healthcare problems. A great number of advanced AI based algorithms are integrated with IoMT to change an early warning system for fast detection of patient illness during post-operative recovery.

Fig 1.2: Artificial Intelligence in Healthcare

1.3.1. Overview of AI Technologies

There has been a recent surge of interest toward AI, mainly because of the introduction of deep learning and artificial neural networks in various applications. This has now resulted in various AI-related approaches in literature such as IoT, big data, cloud computing, edge and fog computing, crowdsensing, blockchain, social networks, and e-Health. AI technologies are proven to be quite useful for providing efficient solutions in different application domains.

Since the outbreak of COVID-19, effort has been made to find fast and efficient solutions to cope with this kind of medical emergency situation. Most AI-based applications or solutions require a vast amount of data to provide a reliable and efficient outcome. Moreover, efficiency is highly sought in providing scalable and feasible solutions, which can be adapted to other scenarios. To date, no other study has been reported following such a technological approach, and there is a lack of studies dealing with the integration of AI to the entire process of patient-centered care systems. Alternatively, an AI-driven environment toward a digital platform for end-to-end settings with a very low data dependency is proposed.

1.3.2. Current Applications in Healthcare

There has been a surge in developing healthcare applications by integrating artificial intelligence (AI) implementations into modern digital health systems. On the other side of the coin, ethical concerns about acceptable levels of machine autonomy in patient care have been getting attention. In this context, systems offering patient-centered care through information transparency and shared decision-making are proposed. Hospital bedside scenarios in the near future are discussed with features of the future care systems that address a balance between machine autonomy and patient autonomy.

There has been a rapid evolution of healthcare-related computer and robotic systems already replacing humans in various tasks. When compared with other fields like automobile and food industry, large scale systems in healthcare are relatively recent. In this context, the rise of artificial intelligence (AI) technology in healthcare promises further replacement of repetitive tasks and actions traditionally done by humans. Accordingly, there is increasing research to find the best way for healthcare systems to harness AI technologies. This topic includes broad areas such as remote monitoring through wearable devices, real time monitoring in intensive care units, drug discovery and treatment, planning patient treatments, performing surgeries, and administrative tasks. Many of these tasks are already done by algorithms showing non-inferiority and even superiority compared to their human counterparts. Since recent advances in AI technology could further boost the development and adoption of AI technologies in medicine, newly emerging AI-healthcare systems are expected to have incredibly good performance in tasks like diagnostics, patient care, and treatment planning. However, ethical questions emerge regarding the level of autonomy granted to machines. Especially when it comes to making decisions in patient care, there is ongoing debate on what is an acceptable level of autonomy.

1.4. Integration of AI into Patient-Centered Care

Driven by a tightly interconnected society, healthcare is tasked to constantly enhance patient health outcomes while also reacting to individual goals and personal situations. With this challenge to provide thorough and comprehensive patient-centered care, recent studies have begun to ask whether patient care can be considered patient-centered when Artificial Intelligence (AI) is integrated as part of healthcare systems. Therein lie opposing sentiments. On the one hand, AI is seen as enhancing clinical work through its data-driven approaches and data processing abilities. Benefiting from new technologies, healthcare outcomes can be improved through better alert systems and AI-generated personal diagnoses, and population health can also be ameliorated by AI through its data analysis and econometric functions. In contrast, on the other hand, AI-generated medical

opinions are also seen to rob patients of personal contact, as they can place patient-doctors in a passive role, and hence reducing the standard of patient care.

Patient-centered care models require active collaboration between patients, families, and healthcare providers. In maintaining a patient-centered approach to care, healthcare providers can uphold the human element by discussing each AI-generated medical opinion with the patient. Patients may also be discontented with healthcare providers that utilize AI technology without their awareness. This transparency towards AI in medical opinions is essential as patients have a significant right to know about a treatment or action being applied to them. Similarly, healthcare providers must also be educated about AI-generated medical opinions. This is so healthcare providers can comprehend the AI-generated medical opinions and thereby effectively explain them to their patients. AI training for healthcare providers is seen as complementing ethical AI initiatives, as healthcare workers will develop an educated understanding about AI medical applications. Since the development of AI technology is revolutionizing healthcare across the board, patient health gains, the AI training of healthcare workers, and patient awareness of AI's capabilities and limitations can promote the best possible healthcare improvements for all individuals.

1.4.1. Enhancing Patient Engagement

The role of AI can largely also be seen in the healthcare sector. It is supposed to be argued that various AI based healthcare practices can largely improve patient-centered care systems as a whole. A variety of AI technologies such as Machine Learning, Predictive Modeling, Data analysis, Natural Language Processing, and Robotics are being used in healthcare by many countries. AI technologies in the healthcare sector can support the medical search to limit the spread of infection, increase effective monitoring of the epidemic and manage the use of scarce medical resources. Countries such as China and America already used AI based robots to manage and curtail COVID-19. Other regions of the world are also potentially utilizing this technology by using AI chat bots in concurrence with health care professionals to give quick responses to the suspect patients via their phone or internet. AI can also contribute largely to the self-reliant healthcare system, enhance the efficiency of the healthcare workforce and health management of large populations, and develop consistent telemedicine and decision support systems. Physically as well AI can be applied in the diagnostic procedures like imaging diagnostics system, predictive analytics of large health data, and enhance understanding of genomics to make more effective decisions. The AI role in health care is increasing day by day, there are 100 countries which are already utilizing the AI healthcare technology. Japan is leading in AI based health technology using robotics, virtual assistive services which ensures a healthy life and improves the efficiency of the

health workforce. On the other hand, other AI technology is also used in other countries like Europe, India, China, America, and Korea etc. AI has demonstrated great promise in widespread healthcare applications and its scope will increase in the near future on the back of emerging trends. The ambition of this article is to serve as a state-of-the-art guide to current AI applications in healthcare, to present a comprehensive overview of studies employing AI in healthcare and possibly inspire individuals to undertake future research in this area.

1.4.2. Improving Clinical Decision-Making

Substantial effort has been concentrated on leveraging AI to advance better and more secure healthcare services. A considerable body of research has been hanging about proposing novel AI methods and models to address different healthcare research problems. Few of the methods have been practiced in real-world settings successfully, on the other hand, many others have been harshly criticized for being non-scalable, untrustworthy, or excessively simulated, which impedes them from being extendible. This necessitates interdisciplinary collaborations involving physicians and medical professionals for advanced solutions to be clinically relevant, usable, and deployed in a scalable and universal manner. Extensive efforts are being made to create proof-of-concept or pilot studies demonstrating the benefits of AI applications in clinical practice. The results, however, have been mixed, with a recent review reporting only little progress in using AI to improve clinical decision-making over the past two decades.

Such collective actions should comprehend the entire development cycle from problem definition to large-scale deployment and encompass (i) the creation of a consensus and standardized framework for curating, annotating data and evaluating models, fostering large, publicly available, and globally accessible benchmarks and collaborations; (ii) the promotion of reproducibility and replicability by accompanying publications with open-source code, documentation, and pre-trained models; (iii) the encouragement of transparent and external validation using real-world data in various geographic settings and healthcare systems; (iv) the advocacy and provision of reasonable and requisite data access and resources, as well as the establishment of sustainable and ethically responsible agreements among all the involved parties; and (v) the establishment of a regulatory and evaluation system to align the development of AI-enabled tools with the improvement of health quality and the reduction of health disparities.

1.5. Challenges in Integrating AI

Patient-centered platforms, such as personal health records and digital health communication systems, are powerful tools for patient engagement and activation in

health care. However, EHR-related burnout presents a risk to patient safety and clinician well-being. Physicians are at high risk for EHR-related burnout due to the longer time they spend on EHR tasks compared with other professions in healthcare.

Second, while AI has the potential to improve patient-centered care, its implementation in real-world practice has been limited. Current methods used for integrating AI in patient care often are focused more on the development and application of specific algorithms, whereas it is vital to integrate AI within sociotechnical systems. Namely, the utility and need for transparency, communicative capabilities, and the mitigation of implicit bias should be addressed in tandem with the integration of AI technologies.

Fig : Artificial intelligence in healthcare: past, present and future

1.5.1. Data Privacy and Security

The integration of artificial intelligence tools into modern healthcare services has the potential to transform and revolutionize patient care. In this new framework, computer algorithms collect and process the large amounts of health-related data produced and gathered by biological sensors and smart mobile devices. These massive amounts of data can be transformed into valuable and useful information for early monitoring, diagnosing, and prognosis activities. This represents an evolution from the actual hospital-centered healthcare delivery systems towards the future, more effective and efficient, patient-centered care administration. The data coming from continuously monitoring the patient's health status will help to develop (and improve) effective healthcare plans, including personalized drug administration and dietary suggestions. However, a plethora of ethical, legal, environmental, and social issues arises with operating a widespread, interconnected, and distributed infrastructure of these AI-empowered systems, from data privacy and security, the interoperability of multi-vendor and multi-site systems, to possible, but non-anecdotic, examples of "killer AI robots and uncontrolled spread of bio cyber attacks".

1.5.2. Ethical Considerations

With the rapidly increasing application of computer and information science in modern smart healthcare devices, ethical considerations have become a key design consideration for healthcare devices in the digital healthcare ecosystem, including medical electronic devices. However, differences in terms of the traditional understanding of ethics in electronic devices compared to novel ethical considerations in AI-driven systems in the emerging interconnected smart healthcare ecosystem require a detailed and careful examination.

1.5.2.1. Transparency and Auditability Guaranteeing transparency of actions is a key consideration when integrating AI modules in smart health devices. The advantage of healthcare AI lies in its learning ability in efficiently perceiving complex trends from a large training set of data. For this reason, deep machine learning shortcomings in traditional interpretable transparent model building are well suited. At the same time, smart healthcare devices will be inevitably confronted with agile integration of models within the life cycle, possibly including the addition or substitution of models by different vendors. In this regard, the Ethical Models, Transparency and Auditability Interview (ETAMI) set proposes ethical guidelines aimed at nicely addressing these ethical-specific issues in smart health devices frameworks.

1.5.2.2. Fairness and Bias The precision of an AI technique is widely recognized to reside with how proficiently the algorithm can learn the underlying traits of the putative

features, and convey this comprehension to classify new instances (or estimate missing values in the case of regression tasks). There is a widening consciousness, however, that 'magic box' black-box ML algorithms exacerbate the likelihood that the technique might be improperly exploited both in the safety-critical fields of healthcare in particular, and in general digital healthcare devices practices.

1.6. Case Studies

Artificial intelligence (AI) techniques are increasingly applied to healthcare for a range of diagnostic and prognostic purposes. Still, the promise of AI to truly integrate and enhance the patient-centered care spectrum by leveraging clinical, imaging, and genetic data remains untapped. Eight case studies present illustrative examples of the successful application of AI techniques in the healthcare setting. They are framed according to an AI workflow, promoting understanding of the breadth and depth of what AI can do and how it might be applied to enhance the clinical value of its outputs. To exemplify the potential clinical value of those AI techniques, eight case studies representing a variety in application of AI techniques are presented. To support clarity of the mechanism by which AI is applied to each challenge, those case studies are framed according to: data sourcing; data processing and algorithm construct; and the algorithm outputs. In light of the potential for AI to have a beneficial impact on healthcare, it is incumbent upon data scientists to engage with clinicians and policymakers to provide transparency in algorithm development and advocate an understanding of how AI can enhance care.

1.6.1. Successful Implementations of AI

With technological advances rapidly developing in an open healthcare market, there is a growing demand for modern healthcare systems to be equipped with artificial intelligence. The goal of this study was to analyze modern healthcare and discuss how it could be redefined by integrating AI into its patient-centered care systems. Challenges and barriers that are encountered have been identified and proposals for addressing them have been discussed. Patient-centered care models could gain benefits of incorporating AI, such as chatbots for routine treatment, telehealth for home health monitoring, compliance with medication treatments, and clinical support in decision-making. More importantly, patient data can be analyzed using deep learning algorithms to understand patterns and trends for predicting, diagnosing, and recommending treatments. Note that in the Near East and Africa (NEA) region, data is scarce due to the lowest health care expenditure globally, but the tables can be turned to an advantage via a more open population data partnership. Each person has more access to digital healthcare with smart devices that provide crucial data about the condition to feed AI algorithms. Working

with healthcare providers to continue the data collection and monitoring process can conduct an analysis based on data driven by AI algorithms and assess the health condition. Better decisions can be made for better care and better understanding of what is happening, the options, and choices that can be made to improve health. With the accumulation of historical healthcare data and current modern training algorithms, deep learning models can predict, analyze, and solve healthcare issues. Vision and language processing for healthcare applications have already allowed researchers to discover early diagnosis of chronic and acute diseases, improvement of emergency room diagnosis and reduction of over-imaging. Plenty of works have focused on in- and out-patients, health data privacy, in monitoring healthcare, opportunities, applications and solutions and conversational agents, environments, and systems. Therefore, modern healthcare redefined by implementing an innovative AI should focus on an open population data partnership to meet the challenges related to data sources, knowledge, economic, and cyber security. There is an urgent need to develop an ongoing data-driven decision for improving the health of patients.

1.6.2. Lessons Learned from Failed Integrations

Patient-centered care has been proposed as a paradigm within healthcare systems. There has been a growing interest in rethinking the concept of patient-centered care within modern healthcare systems by integrating artificial intelligence. Artificial Intelligence (AI) technologies are seen as potential solutions to the challenges of care access and quality. Major telecommunication and e-commerce companies have been investing heavily in recent years in AI in order to develop tools capable of detecting and treating a variety of diseases. This has led to the emergence of a multitude of AI-driven solutions in healthcare, many of which target patients rather than medical professionals.

ARC (analytic, rules-driven, and computerized) support agents capable of actively monitoring and supporting patient progress – including through the Internet of Things (smartphones, wearables, and smart home appliances) – are considered to be an indispensable component of future healthcare systems. These systems could help minimize the need for continuous professional intervention and use medical resources more efficiently. Nevertheless, despite the growing interest in the development and adoption of such systems, only a limited number of AI-driven solutions have managed to gain sustainability within healthcare systems. Out of the 53 AI implementations identified at the National Health Service (UK), 34, although few in number, have been recognized as widespread in nature. As recently pointed out in an extensive review, eHealth technologies have generally not achieved large-scale integration and, where they have been integrated, they often only partially allowed completion of the expected achievements.

1.7. Conclusion

The integration of artificial intelligence into patient centered care systems will redefine modern healthcare delivery. Artificial intelligence allows for a bi-directional enhancement in healthcare interactions via technological systems to deliver the most up-to-date medical research, information, and best practices to practitioners, while simultaneously learning from the practitioner-patient encounter in order to deliver individualized and evidence-based support. AI is arguably the highest priority and consideration for the future of healthcare: with the amount of data generated in healthcare doubling every 73 days, practitioners on average are only able to access as little as 20% of the most up-to-date research and guidelines. But it offers a way to bridge the increasing gap between the growing amount of data and the time-supportive analyses.

Shaping health research and innovation. The AI CMEP seeks to shape Singapore's health research and innovation by investing in foundational AI technologies and creating an open, inclusive and trusted environment that supports AI deployment in healthcare. The AI CMEP co-funds public-private partnership projects that use AI for disease prevention, diagnosis, treatment, monitoring and prognosis. The goal is to develop scalable and clinical deployable AI technologies which have a clear pathway towards commercialization and market deployment at public healthcare institutions in Singapore. Integrated care pathways (ICPs) will define a set of choices, required resources, and interventions for the care of an individual patient with a specific illness, injury, or condition. It provides a sequence and timelines of key steps, based on the best available evidence and eventually tailored to the specific needs of the patient. AI can provide an opportunity for integrated care needs assessment and care planning. Patient's partial data may guide the input for the AI model, and high-risk stratification and clinical decision support (CDS) will be derived by the AI model. Proactive care planning can then be generated for the use of planners and care navigators. Australia's first AI health system is currently being trialed in WA to provide fully automated hypothesis-free and evidence-based assessments of routine healthcare data. This will enable the AI system to generate patient-individual and simulated best practice pathways to guide clinical decision-making and reduce unwarranted variation in care.

1.7.1. Future Trends

Several future trends for artificial intelligence (AI) and robotics in patient-controlled care systems could be anticipated: AI Systems as Trusted Assistants: AI and robotics have the potential to substantially transform diagnosing, treating, and caring. Beyond providing support and information, AI systems will be able to take on more complex tasks and act according to their recommendations, perhaps jointly with human colleagues. This transformation will have to respect the patient's autonomy, privacy, and

dignity. AI in Safety-Critical Decisions: A range of severity can be envisaged in interactions between patients and health-related AI systems. Especially safety-critical decisions, for instance in cancer therapy, could soon mainly be made by consulting AI systems. This raises a number of legal, ethical, and societal challenges. A Holistic Model of the Patient: Care provision is traditionally compartmentalized into diagnosis, treatment, aftercare, and prevention. With the thorough monitoring of a person's health state across an array of (often networked) devices and the application of advanced AI methods, there will be a more holistic approach to understanding and modeling patient situations. This patient model will be instrumental in providing care that is tailored to the person's individual needs. Robotics and Automation: Robotics will (partly) automate many aspects of care or routine therapy. This development entails legal, ethical, and societal challenges as the current professional roles of healthcare practitioners are dependent on them performing such routine tasks. There will also be a need to involve patients in these processes, e.g., by the application of personal robots and telemedicine. Finally, with the reduction in human touchpoints, problems of a technical nature may result, e.g., if an isotropic maintenance module has to operate on a patient who had been receiving radiation treatment.

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