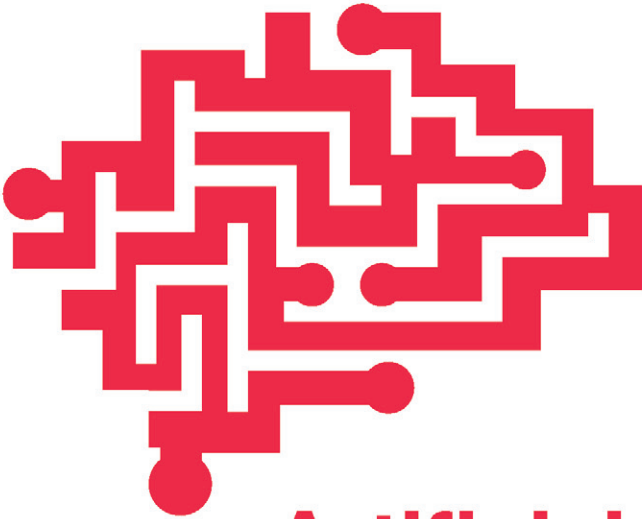


**European Health
Management in Transition**



Artificial Intelligence

**Why and How it
is Revolutionizing
Healthcare
Management**

**Elvira Buijs
Elena Maggioni
Francesco Mazziotta
Gianpaolo Carrafiello
Federico Lega**

ARTIFICIAL INTELLIGENCE

European Health Management in Transition

Series Editors:

Federico Lega, Full Professor of Health Management and Policy, Director of the Research and Executive Education Center in Health Administration, University of Milan.

Books in the series investigate how changes to the health and social care environment are leading to innovative and different practices in health management, health services delivery design, roles and professions, architecture and governance of health systems, patients' engagement and all other paradigmatic shifts taking place in the health context.

The books provide a road map for managers, educators, researchers and policymakers to better understand this rapidly developing environment.

Books in the Series:

Federico Lega and Usman Khan: *Health Management 2.0: Meeting the Challenge of 21st Century Health*

Axel Kaehne and Henk Nies (eds): *How to Deliver Integrated Care: A Guidebook for Managers*

Federico Lega and Giada Carola Castellini: *Resilient Health Systems: What We Know; What We Should Do*

Federico Lega and Angela Pirino: *Developing and Engaging Clinical Leaders in the 'New Normal' of Hospitals: Why it Matters, How To Do It*

Federico Lega and Pia Kreutzer: *Building and Improving Health Literacy in the 'New Normal' of Health Care: Frameworks and Actions*

ARTIFICIAL INTELLIGENCE: WHY AND HOW IT IS REVOLUTIONIZING HEALTHCARE MANAGEMENT

BY

ELVIRA BUIJS

University of Milan, Italy

ELENA MAGGIONI

University of Milan, Italy

FRANCESCO MAZZIOTTA

University of Milan, Italy

GIANPAOLO CARRAFIELLO

University of Milan, Italy

and

FEDERICO LEGA

University of Milan, Italy



United Kingdom – North America – Japan – India
Malaysia – China

Emerald Publishing Limited
Emerald Publishing, Floor 5, Northspring, 21-23 Wellington Street,
Leeds LS1 4DL

First edition 2024

Copyright © 2024 Elvira Buijs, Elena Maggioni, Francesco Mazziotta,
Gianpaolo Carrafiello, and Federico Lega.
Published under exclusive licence by Emerald Publishing Limited.

Reprints and permissions service

Contact: www.copyright.com

No part of this book may be reproduced, stored in a retrieval system, transmitted in any form or by any means electronic, mechanical, photocopying, recording or otherwise without either the prior written permission of the publisher or a licence permitting restricted copying issued in the UK by The Copyright Licensing Agency and in the USA by The Copyright Clearance Center. Any opinions expressed in the chapters are those of the authors. Whilst Emerald makes every effort to ensure the quality and accuracy of its content, Emerald makes no representation implied or otherwise, as to the chapters' suitability and application and disclaims any warranties, express or implied, to their use.

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN: 978-1-83549-471-4 (Print)

ISBN: 978-1-83549-468-4 (Online)

ISBN: 978-1-83549-470-7 (Epub)



INVESTOR IN PEOPLE

CONTENTS

<i>About the Authors</i>	<i>vii</i>
<i>Preface</i>	<i>ix</i>
1. Introduction to Artificial Intelligence in Healthcare	1
2. Artificial Intelligence and Healthcare Applications	21
3. AI Applications in the New Era of Healthcare and Community Care	49
4. Key Emerging AI Developments in Healthcare	65
5. A Guide to Implementing AI in the Workflow	85
Afterword: Why AI Is Relevant for Clinical Leaders	101

This page intentionally left blank

ABOUT THE AUTHORS

Elvira Buijs is a radiology resident at the University of Milan, Italy, and healthcare consultant. She earned a Master's degree in Economics and Healthcare Management (MIHMEP) from the Bocconi School of Management. As a Strategy Consultant with the Boston Consulting Group, she collaborated with healthcare companies, government agencies, and foundations across Europe and the United States. Her research interests are healthcare organization and management, strategy, optimization and quality of care. Her articles have appeared in peer-reviewed scientific journals.

Gianpaolo Carrafiello is a Full Professor of Radiology at the University of Milan, Italy, and the Director of postgraduate school of nuclear medicine. As an interventional Radiologist, he specializes in IR management of extra-vascular and vascular diseases. He is part of the review board of several important indexed journals, reviewer of numerous IR international journals and author of more than 260 articles published in indexed journals. He is an expert in highly technological interventions and has published several papers in the field of AI and radiomics.

Federico Lega, PhD, is a Full Professor of health administration at Public Health Department, University of Milan, where he holds courses in healthcare management and policy for

medical students and leads the Research Centre in Health Administration (HEAD). A member of hospital administration boards and local health agencies, he is a consultant to regional health departments, national health agencies and insurances and the World Health Organization. He has been President of the European Healthcare Management Association (EHMA) and the Chair of its scientific advisory committee. Since 2015, he is the Editor in Chief of the research journal *Health Services Management* and an Associate Editor of *BMC Health Services Research* and the *Medical Care Research and Review*. He has published eight books and over 150 journal articles.

Elena Maggioni is a Research Fellow in health administration at the Research Centre in Health Administration (HEAD), University of Milan, Italy. She earned a Bachelor's degree in Economics and Management from Bocconi University, then a postgraduate degree in the management of healthcare organization and healthcare from the University of Milan. Her research interests are healthcare policies, healthcare organization and management, modernization and innovation in health service delivery, developments in competitive strategies in the pharma and medical device industry, chronic care management and clinical pathways integrating the hospital and the community.

Francesco Mazziotta is a Resident Physician in hygiene and public health, University of Milan, Italy. He earned a degree in medicine and surgery from the University of Milan. During the COVID-19 pandemic, he worked at a mass vaccination centre and in agencies for medical and hospital management and public health. His key interest is in how organizations can optimize clinical practice to improve the quality of care.

PREFACE

Reflections on Artificial Intelligence and Health
Management: What We Know, What We don't Know,
and What We Should Know

Federico Lega
University of Milan, Italy

The artificial intelligence (AI) revolution has begun. Yet, as in the early stages of all revolutions, we know the triggers and the promises, but we don't know much about current and possible developments, positive and negative collateral effects. Public and scientific debate is divided into two camps: the opponents raise an alarm about the potential risks of AI, while the advocates rally in boundless optimism about the unprecedented benefits that AI will bring to the future of humanity. Media coverage fuels the conflict.

A closer look at the healthcare and life science sector reveals both a positive and a negative side – there are high expectations that AI will bring improved accuracy, safety, speed and efficiency to clinical decision-making but also ethical dilemmas, operational challenges and wide-reaching changes in the labour market. The ethical issues are of particular importance, since AI applications for clinical use

will need to weigh choices with complex trade-offs involving financial sustainability and cost-effectiveness. Studies have shown that AI can develop greater empathy than real physicians can; nevertheless, decisions on the best course of treatment for complex cases should not be left to AI algorithms, especially if we don't know which data the AI algorithm was fed. From an operational perspective, the central problem is supervising and controlling how, by whom, with what and when AI in clinical practice will be fed and trained.

Additional questions regard how many AIs can or should operate in a health system. Do they need authorization? Who has the right to develop them? Furthermore, how will AI affect the medical workforce and clinical researchers? How will healthcare organizations build their competitive advantage when AI applications are ubiquitous throughout a healthcare system (and yes, they need to be for the sake of equity), steadily encroaching on the professionalism established in years of personal study, practice, research and investment. How can life science change its inner dynamics of research and competition?

Presently, we do not know enough to answer these questions.

We know that AI performs better than real doctors, on average, in making an appropriate diagnosis and prescribing therapy in clinical decision-making. We know that its performance depends on how AI is fed and trained, as it will amplify biases present in the training data. For instance, distorted representation or unfair treatment of patients based on race, sex, language and ethnicity.

But we still don't know enough. We don't know how to manage the ethical issues AI raises. We don't know who will certify AI and how to counterbalance the agency's power. Who will decide who will feed it or how to design an authorization/

accreditation system for AIs in the health system or in a single organization?

We don't know how it will impact human resources for the implications for systems and organizations. What will the consequences be for countries like Italy, the United Kingdom, Scandinavia, Spain and Portugal where the public national health service is a major national employer, and the local health organization or hospital is the largest employer and driver of the local economy in some geographical areas?

These issues regard the political and the institutional environment, involve setting limits and authorization for the uses of AI in healthcare, responsibilities for its development and maintenance and means to guarantee equity in its accessibility and availability within the whole health sector. They should be on the agenda of politicians and authorities. For the governance of the health and life science sector. For the regulators and administrators of the system and the healthcare sector.

But these issues are not the focus of this book. Nor should they be on a health manager's strategy agenda. You won't find them addressed here.

So what can the reader expect to find? Everything related to the managerial responsibility of a hospital and health organization leader. Which is quite a tall agenda. Many aspects of AI that we should know and are often neglected or ignored by current research and debate.

If, for once, we turn away from the dominant perspective (and threat) of AI as a 'doctor' (or as a substitute for doctors, nurses or other health professionals) and try to envision its potential contribution to the management and the operations of a healthcare organization, we may then explore a new realm of possibilities. That's exactly what we should do and know. What we need to know if we want to improve the

proficiency of healthcare leaders in managing the adoption of AI in their organization.

There are myriad potential AI applications that extend beyond clinical care decision-making to include improvement in organizational dynamics that AI can facilitate, support, enhance and augment. This is the focus and the core of the book, the key content of the research presented here. The work is centred on the managerial and the operational implications (opportunities and changes) for the adoption of AI by a health organization, from board room to bed side. The book was designed to provide health managers and decision-makers with a framework for action, grounded on solid analysis of theory and evidence. The framework is developed through the central chapters of the book, following the introduction to AI and before the final chapter on issues in AI implementation.

An overview of the book's contents is given in Fig. 1 which illustrates the diverse impacts of AI on a healthcare organization beyond the usual area of support or substitution in clinical care decision-making. In this perspective, AI can serve several different areas of organizational operations and management, such as:

- Support, redesign and improve delivery processes. For instance, AI can impact scheduling, staff labour division, technology maintenance and planning, among others.
- Support and enhancement of clinical management functions, e.g. risk management, clinical governance, clinical competence management. For instance, analysis of organizational data, building of casual interrelationships, continuous comparison with research evidence, gold standards and best competitor performance can provide valuable feedback to inform efforts to minimize risk, facilitate option of best-in-class practices, assure continuous customized training and workforce re-training.

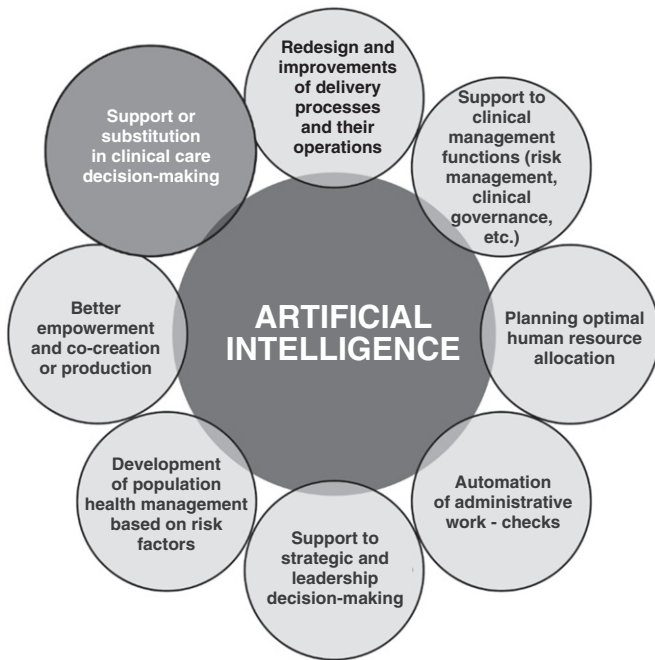


Fig. 1. Potential Impact of AI on Healthcare Management Dynamics. Source: The author.

- Planning optimal human resource allocation, from effective staff sizing and composition (skills mix) throughout a healthcare organization/hospital to planning short- and long-term recruitment policies.
- Automation of administrative tasks and controls. Bureaucracy can be substituted or managed more efficiently through AI, with improvement expected in speed, accuracy and streamlining. Whether the production of documents (e.g. certificates, clinical records) or payment management, substantial improvement can be expected.

- Support in strategic and leadership decision-making. Big data analysis, scenario writing, simulations, correlations, forecasts, plus all the information that AI can process and re-organize could impact the capacity and the capability of leadership in hospitals and healthcare organizations.
- Development of new and more effective approaches to population health management thanks to AI's greater capacity to generate and control risk factors associated with the healthy or chronic care population. Recognition of patterns through which AI can anticipate health status changes and/or new correlations between health indicators, behaviours, therapies, environment and health literacy can be an extremely powerful capability for healthcare organizations and systems to shift from reactive to proactive medicine.
- Greater empowerment and co-creation and co-production of services. For instance, AI can meet the needs of patients with chronic conditions and afford them better self-management of their illness. Alternatively, AI can support healthy citizens in maintaining their health through adaptive well-being behaviours and lifestyles.

All in all, AI holds promise for hospitals and healthcare organizations in their quest for better productivity, quality and sustainability. The development of AI for clinical use is well underway. The pharmaceutical and the medical device industries are competing for direct returns on investment in their business and for the chance to win a greater share of the current market or enlarge it (e.g. better adherence to therapy, risk factor control, prevention, novel therapies for rare diseases), whereas research and development of AI for management, operations and administration of hospitals and healthcare organizations lag far behind. Our case review presented here provides healthcare managers and top leaders

with a glimpse of what the near future holds when AI is deployed to serve the management dynamics of their organization. Furthermore, analysis and framing of the impacts AI can have on administrative processes and on operations of clinical delivery pathways provide insights for managers and clinical leaders engaged in planning the adoption and managing the implementation of AI for organizational tasks.

Finally, the investigation of AI and its potential role in the evolution of health systems from reactive to proactive postures is enlightening and reveals an opportunity that policymakers, leaders and managers cannot miss. Nothing will be as it used to be. Nothing will be the same. On the verge of this revolution, we believe that leaders at all levels of health systems, organizations and hospitals should acquire a better understanding of AI if they want to guide its introduction, adoption and implementation effectively. It is our hope that readers will find the discussion interesting and take it as a call to action.

This page intentionally left blank

INTRODUCTION TO ARTIFICIAL INTELLIGENCE IN HEALTHCARE

ABSTRACT

Implementing artificial intelligence (AI) in healthcare organizations involves the entire organization. This groundbreaking technology is becoming central to achieve the goals of the new healthcare through the ongoing commitment to sustainability despite the severe lack of resources. Decision-makers in healthcare need knowledge and skills to prepare for the changes in many professional activities in the years ahead. Furthermore, chief medical officers and clinical leaders need to act on the opportunities that AI can bring, starting from its integration into the reality of healthcare settings while working with those responsible for managing and implementing AI in compliance with current legislation in Europe and the United States. Finally, stakeholders need to know how to leverage AI capabilities and how to recognize its limitations and its opportunities in administrative applications (admin AI) to optimize day-to-day operations and clinical applications (non-admin AI). In this view, clinical leaders and health

care decision-makers may appreciate AI as a new way to provide sustainable social and healthcare services.

Keywords: Artificial intelligence; healthcare; admin AI; implementation; integration; opportunities; supervised learning; management; governance; reengineering

Can a machine think?

(Turing, 1950)

An unparalleled innovation of the 21st century, artificial intelligence (AI) is a major driver of technological growth, discovery and research. It can be defined as the ability of a machine or a software programme to perform cognitive tasks typical of human intelligence, like reasoning, problem-solving, pattern recognition and autonomous decision-making (eit Health, 2020; Russell & Norvig, 2016). Programmed to think and learn like human beings, it solves problems by drawing on extensive data sets and performs tasks that typically require human intelligence. Hence, the study of AI comprises diverse fields of knowledge that have converged to revolutionize technology and science, with the promise of transforming our ability to understand machines and their possibility to emulate human intelligence.

AI IN HEALTHCARE: A HISTORICAL PERSPECTIVE

The history of AI is rooted in speculation by philosophers and mathematicians about whether the concept of intelligence can be applied to a machine or an artificial construct. Such ideas can be traced back to ancient legends. It is only since the 20th century, however, that AI has started to take shape and evolve into a field of research. The chapter's opening quote is taken from a manuscript written by Alan Turing, one of the 20th century's

brilliant minds, mathematician, logician, cryptanalyst and computer scientist. During the Second World War, Turing used machines and computers to develop the Turing machine, a theoretical device that formalized the notion of algorithmic computation and laid the foundation for modern computer science and the Turing test, a criterion for determining whether or not a machine exhibits intelligent behaviour. Crucial to intercept and decrypt enemy messages during the War, Turing's work was a milestone in AI.

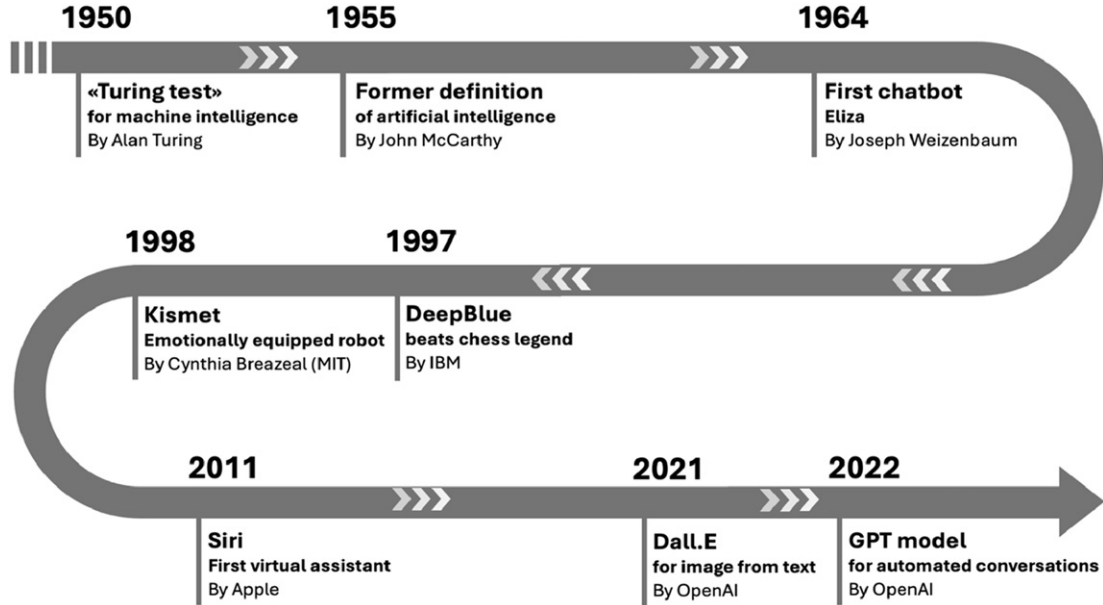
At some point in the 1950s, John McCarthy coined the term 'AI'. Economic resources permitting, research began to grow rapidly. In McCarthy's day, it was thought that machines could be taught to perform a variety of tasks: voice recognition, understand natural language, identify objects, engage in deductive reasoning and formulate new mathematical theorems. With hindsight, the founding fathers were onto something. In the 1960s, researchers developed programmes that could solve simple and linear algebraic problems, interact with people (e.g. Eliza Chatbot by J. Weizenbaum) and play chess in a challenge to the human mind, such as the DeepBlue calculator. But researchers also tried to teach robot to recognize and simulate emotions. The first was Kismet, a robot head with human traits designed by the Massachusetts Institute of Technology. Early applications of AI in healthcare can be traced to the 1960s and 1970s when AI systems were used to support medical decision-making in chemistry and clinical microbiology. The initial demonstrations generated enthusiasm, and the possibilities were just beginning to become clear. Although these were huge steps forward, it was not yet possible to consider them 'intelligent' machines because they were unable to detach themselves from provided inputs to generate outputs.

Thanks to the growth of computing power and the abundance of available data, AI has quickly reached ever greater heights. Moreover, software programmes can modify their own

code using outputs derived from human inputs as inputs themselves. There are numerous examples in healthcare and other areas. For instance, self-driving cars work on a combination of sensors, cameras, radar and AI to read and react to external stimuli. The relevance of AI for mobility applications has attracted considerable interest, with car manufacturers investing in the market: it is estimated that it could generate a business volume of between \$300 and \$400 billion by 2035 (Deichmann et al., 2023). AI applications will then become exportable to other sectors. Intelligent virtual assistants (IVA), AI-based chatbots that interact with humans in conversation (e.g. Siri) and software that produces text and images that are difficult to distinguish from those created by humans (e.g. Dall.E, ChatGPT or Midjourney) are changing education, information, finance and accounting (Burns & Igou, 2019; Gubareva & Lopes, 2020; Liu et al., 2023; Priya & Sharma, 2023). Furthermore, AI has entered people's homes through the chips ubiquitous in household appliances (Caffo, 2023) like the smart refrigerators and washing machines that reduce energy consumption and waste. This progression is mapped in Fig. 2.

DEFINITION AND CORE SUBSETS OF AI

The definition of AI might seem straightforward, yet it conceals intricate concepts and eludes even the scientific community. While AI, machine learning (ML), deep learning (DL) and neural networks (NNs) are frequently used interchangeably, each is a constituent of the preceding one and should be kept distinct from the others. To understand the differences, readers need to keep in mind what computer algorithms and computational models are. The former are coded instructions that take input data, perform computations and generate



Source: The authors.

Fig. 2. A Timeline of Progress in Artificial Intelligence Applications.

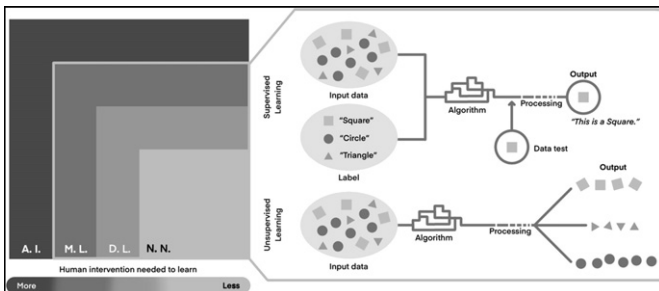
output to solve specific problems, while the latter are mathematical or logical descriptions of how various components within a system interact with each other to produce certain outcomes. ML involves generating algorithms that enable computers to learn from data, make predictions or decisions without explicit programming, recognize patterns, extract insights and generate predictions autonomously. The data characteristics that an algorithm can be instructed to identify or that it can autonomously uncover are referred to as features. A key aspect of ML resides in an algorithm's ability to learn from the data itself with increasing effectiveness as it is exposed to more and more data.

NNs are computational models akin to the structure of biological NNs. They consist of interconnected nodes organized into layers that process input signals to recognize patterns, classify data and make predictions through learning. DL refers to the utilization of multilayered artificial NNs to model and process complex patterns in copious amounts of data, thus enabling machines to perform image and speech recognition, natural language processing and decision-making with high accuracy. A multilayered NN consists of layers of nodes between the input and the output layers. Each layer processes the input data and passes it to the next layer, with each consecutive layer building upon the representations learnt by the previous layers. Being stacked in multiple layers, a network can extract progressively higher level features from the input data, enabling it to learn more complex patterns and relationships.

ML falls under the umbrella of AI, where DL is a subset of ML, and NNs form the core of DL algorithms. NNs emulate the human brain by using a set of algorithms, while DL pertains to the depth of layers within an NN. ML relies more on human intervention for learning compared to DL ([eIT Health, 2020](#)).

A hallmark characteristic of algorithms at the base of AI is that they can learn in a supervised or unsupervised fashion (Panesar et al., 2019). Supervised learning trains the system by labelling each input with its desired output value, while unsupervised learning generates inferences without the labels (Sindhu Meena & Suriya, 2020). This difference is important for the implementation of AI in healthcare since there are labels for some fields but not for all. Automatic classification of emails and price predictions are examples of supervised learning. Algorithms can aid in medical diagnosis through supervised learning, drawing on classification of inputs from clinical guidelines. Differently, algorithms based on unsupervised learning may help disclose insights into patterns, structures or relationships in data without the need to label them beforehand. This type of AI can be applied in population or patient segmentation within a specific setting. An overview of this is provided in Fig. 3.

Advanced systems for medical diagnosis and healthcare delivery support will be discussed in the following chapters. AI is a key tool in drug development, from drug discovery and design, identification of drug targets to prediction of adverse events and predictive modelling in clinical trials. AI can also



Source: The authors.

Fig. 3. Overview of AI and Its Subsets.

be applied to drug distribution and marketing (Vora et al., 2023), with clear advantages for the entire value chain for companies and patients.

HEALTHCARE APPLICATIONS: A FRAMEWORK BY PURPOSE

AI has proven to be a game changer wherever implemented, and healthcare is no exception. Healthcare could benefit from the widespread integration of AI: improvement in the quality of care, shortened waiting times and waiting lists and alleviation of work-related stress, thus reducing the risk of burnout in healthcare workers. AI could optimize workload and provide support for continuous professional development, given the rapid advancement of medical knowledge.

For the purposes of this manual, we distinguish between non-administrative and administrative AI applications. The former are clinical or surgical in scope. Hence, non-admin or clinical AI provides diagnostic support, risk analysis of surgical procedures and risk assessment among other activities based on clinical data sets. Differently, admin AI refers to the optimization of organizational processes through the support provided by decision-makers in various settings and organizational levels. Admin AI supports workflow organization, choices dictated by activity volume and multiple variables affecting a particular context (e.g. epidemiology, sociocultural level, race) and the organization (e.g. professional staff). Admin AI can improve work shift management, outpatient scheduling, warehouse management and big data processing for reporting and other time-consuming or energy-consuming tasks (Chen & Decary, 2020; Dash et al., 2019; Houfani et al., 2022; Knight et al., 2023; Syed & Zoga, 2018). Such