كليـــــــة الـطـب
والصيدلة - مراكش
FACULTÉ DE MÉDECINE
ET DE PHARMACIE - MARRAKECH

MARRAKECH
جامعة القاضي عياض
UNIVERSITÉ CADI AYYAD

Year 2024 Thesis N°422

The Impact of Artificial Intelligence on Medical Practice: Hopes and Concerns of Physicians and Patients in the Moroccan context

THESIS

PRESENTED AND DEFENDED PUBLICLY ON 14/11/2024

BY

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Born on November 25th,1999, in Marrakech

TO OBTAIN THE DEGREE OF DOCTOR OF MEDICINE

KEYWORDS

Artificial intelligence – Medical practice – Expectations – Concerns – Moroccan context

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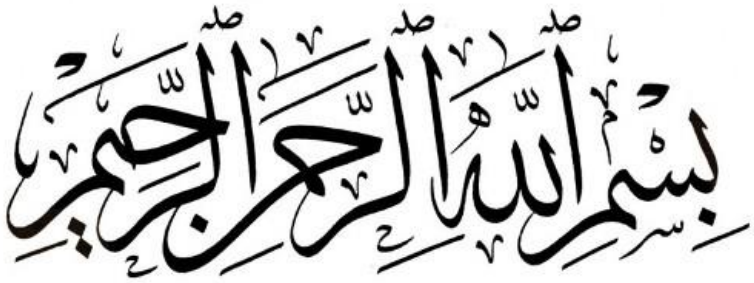
{رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ
الَّتِي أَنْعَمْتَ عَلَيَّ وَعَلَى وَالِدَيَّ
وَأَنْ أَعْمَلَ صَالِحًا تَرْضَاهُ وَأَصْلِحْ
لِي فِي ذُرِّيَّتِي إِنِّي تُبْتُ إِلَيْكَ
وَإِنِّي مِنَ الْمُسْلِمِينَ}

سورة الأحقاق الآية 15


بسم الله الرحمن الرحيم

قَالُوا۟ سُبْحَٰنَكَ لَا عِلْمَ لَنَآ إِلَّا مَا عَلَّمْتَنَآ ۖ إِنَّكَ أَنتَ ٱلْعَلِيمُ ٱلْحَكِيمُ ﴿٣٢﴾


صدق الله العظيم

سورة البقرة ٢:٣٢

Hippocratic Oath

I swear to fulfill, to the best of my ability and judgment, this covenant:
I will respect the hard-won scientific gains of those physicians in whose steps I walk, and gladly share such knowledge as is mine with those who are to follow.
I will apply, for the benefit of the sick, all measures that are required, avoiding those twin traps of overtreatment and therapeutic nihilism.
I will remember that there is art to medicine as well as science, and that warmth, sympathy, and understanding may outweigh the surgeon's knife or the chemist's drug.
I will not be ashamed to say "I know not," nor will I fail to call in my colleagues when the skills of another are needed for a patient's recovery.
I will respect the privacy of my patients, for their problems are not disclosed to me that the world may know. Most especially must I tread with care in matters of life and death. If it is given me to save a life, all thanks. But it may also be within my power to take a life; this awesome responsibility must be faced with great humbleness and awareness of my own frailty. Above all, I must not play at God.
I will remember that I do not treat a fever chart, a cancerous growth, but a sick human being, whose illness may affect the person's family and economic stability. My responsibility includes these related problems, if I am to care adequately for the sick.
I will prevent disease whenever I can, for prevention is preferable to cure.
I will remember that I remain a member of society, with special obligations to all my fellow human beings, those sound of mind and body as well as the infirm.

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228	SLIOUI Badr	Pr Ass	Radiologie
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230	YAHYAOUI Hicham	Pr Ass	Hématologie

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232	MOUGUI Ahmed	Pr Ass	Rhumatologie
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273	MOUROUTH Hanane	Pr Ass	Anesthésie-réanimation
274	BOUZID Fatima zahrae	Pr Ass	Génétique
275	MRHAR Soumia	Pr Ass	Pédiatrie
276	QUIDDI Wafa	Pr Ass	Hématologie
277	BEN HOUMICH Taoufik	Pr Ass	Microbiologie-virologie
278	FETOUI Imane	Pr Ass	Pédiatrie
279	FATH EL KHIR Yassine	Pr Ass	Traumato-orthopédie
280	NASSIRI Mohamed	Pr Ass	Traumato-orthopédie
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286	HAMOUCHE Nabil	Pr Ass	Néphrologie

287	ELMARDOULI Mouhcine	Pr Ass	Chirurgie Cardio-vasculaire
288	BENNIS Lamiae	Pr Ass	Anesthésie-réanimation
289	BENDAOUD Layla	Pr Ass	Dermatologie
290	HABBAB Adil	Pr Ass	Chirurgie générale
291	CHATAR Achraf	Pr Ass	Urologie
292	OUMGHAR Nezha	Pr Ass	Biophysique

293	HOUMAID Hanane	Pr Ass	Gynécologie-obstétrique
294	YOUSFI Jaouad	Pr Ass	Gériatrie
295	NACIR Oussama	Pr Ass	Gastro-entérologie
296	BABACHEIKH Safia	Pr Ass	Gynécologie-obstétrique
297	ABDOURAFIQ Hasna	Pr Ass	Anatomie
298	TAMOUR Hicham	Pr Ass	Anatomie
299	IRAQI HOUSSAINI Kawtar	Pr Ass	Gynécologie-obstétrique
300	EL FAHIRI Fatima Zahrae	Pr Ass	Psychiatrie
301	BOUKIND Samira	Pr Ass	Anatomie
302	LOUKHNATI Mehdi	Pr Ass	Hématologie clinique
303	ZAHROU Farid	Pr Ass	Neurochirurgie
304	MAAROUFI Fathillah Elkarim	Pr Ass	Chirurgie générale
305	EL MOUSSAOUI Soufiane	Pr Ass	Pédiatrie
306	BARKICHE Samir	Pr Ass	Radiothérapie
307	ABI EL AALA Khalid	Pr Ass	Pédiatrie
308	AFANI Leila	Pr Ass	Oncologie médicale
309	EL MOULOUA Ahmed	Pr Ass	Chirurgie pédiatrique
310	LAGRINE Mariam	Pr Ass	Pédiatrie
311	OULGHOUL Omar	Pr Ass	Oto-rhino-laryngologie

312	AMOCH Abdelaziz	Pr Ass	Urologie
313	ZAHLAN Safaa	Pr Ass	Neurologie
314	EL MAHFOUDI Aziz	Pr Ass	Gynécologie-obstétrique
315	CHEHBOUNI Mohamed	Pr Ass	Oto-rhino-laryngologie
316	LAIRANI Fatima ezzahra	Pr Ass	Gastro-entérologie
317	SAADI Khadija	Pr Ass	Pédiatrie
318	DAFIR Kenza	Pr Ass	Génétique
319	CHERKAOUI RHAZOUANI Oussama	Pr Ass	Neurologie
320	ABAINOU Lahoussaine	Pr Ass	Endocrinologie et maladies métaboliques
321	BENCHANNA Rachid	Pr Ass	Pneumo-phtisiologie
322	TITOU Hicham	Pr Ass	Dermatologie
323	EL GHOUL Naoufal	Pr Ass	Traumato-orthopédie

324	BAHI Mohammed	Pr Ass	Anesthésie-réanimation
325	RAITEB Mohammed	Pr Ass	Maladies infectieuses
326	DREF Maria	Pr Ass	Anatomie pathologique
327	ENNACIRI Zainab	Pr Ass	Psychiatrie
328	BOUSSAIDANE Mohammed	Pr Ass	Traumato-orthopédie
329	JENDOUZI Omar	Pr Ass	Urologie
330	MANSOURI Maria	Pr Ass	Génétique
331	ERRIFAIY Hayate	Pr Ass	Anesthésie-réanimation
332	BOUKOUB Naila	Pr Ass	Anesthésie-réanimation
333	OUACHAOU Jamal	Pr Ass	Anesthésie-réanimation
334	EL FARGANI Rania	Pr Ass	Maladies infectieuses
335	IJIM Mohamed	Pr Ass	Pneumo-phtisiologie
336	AKANOUR Adil	Pr Ass	Psychiatrie

337	ELHANAFI Fatima Ezzohra	Pr Ass	Pédiatrie
338	MERBOUH Manal	Pr Ass	Anesthésie-réanimation
339	BOUROUMANE Mohamed Rida	Pr Ass	Anatomie
340	IJDDA Sara	Pr Ass	Endocrinologie et maladies métaboliques
341	GHARBI Khalid	Pr Ass	Gastro-entérologie
342	ATBIB Yassine	Pr Ass	Pharmacie clinique
343	EL GUAZZAR Ahmed (Militaire)	Pr Ass	Chirurgie générale
344	MOURAFIQ Omar	Pr Ass	Traumato-orthopédie
345	HENDY Iliass	Pr Ass	Cardiologie
346	HATTAB Mohamed Salah Koussay	Pr Ass	Stomatologie et chirurgie maxillo-faciale

Liste arrêtée le :
04/10/2024

DEDICATIONS

« Soyons reconnaissants aux personnes qui nous donnent du bonheur ; elles sont les charmants jardiniers par qui nos âmes sont fleuries »

Marcel Proust.

Je me dois d'avouer pleinement ma reconnaissance à toutes les personnes qui m'ont soutenue durant mon parcours, qui ont su me hisser vers le haut pour atteindre mon objectif. C'est avec amour, respect et gratitude que

Je dédie cette thèse …

Tout d'abord à Allah,

اللهم لك الحمد حمداً كثيراً طيباً مباركاً فيه عدد خلقك ورضى نفسك وزنة عرشك ومداد كلماتك اللهم لك الحمد ولك الشكر حتى ترضى ولك الحمد ولك الشكر عند الرضى ولك الحمد ولك الشكر دائماً وأبداً على نعمتك

À la mémoire de mes grands-pères SABIK Ali et TAZROUT Moha

J'aurais tant souhaité votre présence galvanisante à nos côtés, malheureusement le destin en a voulu autrement. J'espère que de là-haut, vous sauriez être fiers de votre petit-fils qui vous aime. Puisse Dieu, tout puissant, vous accorder sa grâce, sa miséricorde et vous accueillir dans son vaste et éternel paradis.

À la mémoire de ma très chère grand-mère

Ta gentillesse envers tous ceux qui t'entouraient était incomparable, ton sourire chaleureux et la brillance de tes yeux resteront à jamais gravés dans nos cœurs. Tu as vécu ta vie dans la paix, en répandant amour et réconfort autour de toi. Je sais, avec certitude, que tu continueras à veiller sur nous depuis le paradis. Tu es à jamais dans nos pensées et nos prières, et ton héritage d'amour vivra en nous.

À la mémoire de ma chère tante Malika TAZROUT

Ton sourire réconfortant et ta générosité demeureront pour toujours dans nos mémoires. Depuis ton départ, un vide immense s'est installé, mais chaque souvenir de toi est un trésor que je chéris profondément. Tu es profondément aimée et tu nous manques terriblement. Que ton âme repose en paix au paradis, entourée de tout l'amour que tu as si généreusement partagé.

À ma très chère grand-mère

Ta présence est un véritable cadeau dans ma vie. Ton amour inconditionnel et tes encouragements m'ont toujours donné la force d'avancer. Chaque moment passé avec toi est précieux, et je chéris toutes les histoires, les rires et les leçons que tu m'as offerts. Que Dieu te préserve et te garde en bonne santé, car tu es notre force et notre inspiration. Je t'aime plus que les mots ne puissent le dire.

À ma très chère mère TAZROUT Hasna

À la plus douce et la plus merveilleuse de toutes les mamans. Merci du fond du cœur pour tout ce que tu as fait pour moi. Ma gratitude est immense pour toute l'éducation et les valeurs que tu m'as transmises. Ta tendresse, ton énergie et ton amour incommensurables m'ont façonné et m'ont soutenu à travers chaque étape de cette aventure. Aucune parole ne peut être dite à sa juste valeur pour exprimer mon amour et mon attachement à toi. Puisse Dieu, tout puissant, te protège, te garde en bonne santé, t'inonde de bonheur et te procurer longue vie afin que je puisse te rendre tout le bien que tu m'as offert.

À mon très cher père SABIK Mohammed

Au plus sage et au plus admirable de tous les pères. Ton exemple a guidé mon chemin, et aujourd'hui, je marche sur tes traces. Ton soutien constant durant mes études m'a été inestimable. Grâce à toi, je suis devenu l'homme que je suis aujourd'hui. J'espère te rendre fier chaque jour davantage. Alors je profite de cette occasion pour honorer l'homme que tu es, l'homme qui m'a appris le sens du travail et de la responsabilité, l'homme qui a toujours été pour moi l'exemple du père respectueux, rigoureux et honnête. Mes mots peuvent difficilement traduire tout mon respect, ma gratitude et mon amour. Que Dieu t'offre santé, prospérité et longévité.

To my lovely Sisters SABIK Hana, Bouchra and Hiba

Thank you for being my unwavering support and my best friends. Your laughter, kindness, and unique personalities have filled my life with joy. I cherish every moment we share and the bond we have. Each memory is a treasure I hold close. This journey wouldn't have been the same without each of you by my side, lifting me up and encouraging me through every challenge. Your love means the world to me, and I am so grateful to have you in my life. I love you all dearly.

À mon très cher oncle Monsieur Jawad

Plus qu'un oncle, tu as été pour moi un grand frère et un ami inestimable. Ton soutien indéfectible et tes conseils précieux ont véritablement façonné mon parcours. Tu es incontestablement la personne la plus pétillante de la famille ; ton sens de l'humour et tes récits captivants apportent toujours une touche de joie. Je te dédie ce travail en témoignage de ma profonde gratitude et de l'immense respect que je te porte.

À mes oncles et tantes, cousins et cousines, aux membres de ma famille, petits et grands,

Merci pour vos encouragements et votre soutien tout au long de ces années. Je dédie ce travail en reconnaissance de la grande affection que vous me témoignez, et pour exprimer toute la gratitude et l'amour que je vous porte.

To my dearest friend BOURI M'hammed Taoufik

Since the first year of medical school, you have been the first person I met at the university and a constant source of support, a true brother. We prepared for exams together, sharing both the challenges and the laughter along the way. I am grateful for every moment we've shared. I truly hope for you a great career ahead, filled with success and fulfillment.

To my dearest friend NOUHI Anas

Even though we didn't meet until the later years of medical school, it really feels like we've known each other forever. The experiences we've shared have built a valued friendship. I truly hope your career flourishes, and that we can be there for each other as you face the challenges and celebrate the successes ahead.

To my dearest friend LAHMAIN Yassine

You're more than a friend; you're a true brother. Your support and motivation have pushed me to new heights, both in the gym and beyond. I'm grateful for every challenge we've tackled together. After all, having a gym buddy makes it easier to lift heavy and skip excuses. Here's to many more gains to come.

To my dearest friend JOUNDI Alaa Eddine

Our late-night study sessions turned into moments of laughter and bonding as we tackled every exam that came our way. Whether we were exploring new cafés or battling it out in video games and gym sessions, every adventure with you has been a highlight of this journey. Your unwavering support and genuine friendship are truly invaluable. As we both embark on our careers, I wish you nothing but success and joy.

To all my dearest friends and colleagues,

Anas, Haytam, Omar, Hamza, Yassine, Ayoub, Wassim, Meryem, Ikram, ...

Throughout all these friendship years, we have faced highs and lows, yet with you by my side, I fondly recall the exciting and memorable moments. Wishing each of you a life filled with satisfaction and success.

Au groupe 11 :

Depuis les premiers cours à la faculté jusqu'aux derniers stages hospitaliers ensemble, nous avons partagé tant de moments inoubliables, des expériences enrichissantes et des souvenirs précieux. Votre soutien et notre camaraderie ont rendu ce parcours encore plus spécial.

To all my teachers and friends from Le Sud School

I dedicate this work to all those who are dear to me, including those whom I may have unintentionally failed to mention.

My wish for you all is to experience abundant happiness, great success, and good health. Thank you

Finally, I wish to extend my thanks to everyone who contributed to this thesis, namely:

All the Doctors and Patients who participated in this study generously dedicating their time to my research.

ACKNOWLEDGMENTS

To Professor BOURROUS Mounir,
my Dear Master and thesis Judge,
Professor of Pediatrics and Chair of the Pediatrics Emergency Department at the Mohammed VI University Hospital of Marrakesh,

You have granted us a monumental honor by agreeing to be the chair for the defense of my thesis. I have always admired your compassionate nature, which enhances your already prodigious knowledge and expertise, something every patient and student of yours can surely attest to. This work is a testament to my deep admiration for all your scientific and human qualities. Your unwavering support and dedication to your students have left an indelible mark on our lives. As a gesture of my appreciation and acknowledgment of your profound influence, please accept my heartfelt respect and sincere gratitude.

To Professor AIT BATAHAR Salma,
my Dear Master and thesis Supervisor,
Professor of Pneumo-phtisiology
at the Mohammed VI University Hospital of Marrakesh.

I still remember the first time I attended your class, which you uniquely chose to conduct in English. I was impressed by your commanding presence and mastery of your specialty. That moment marked the beginning of my desire to produce a work under your exceptional guidance. You have truly inspired me to strive for excellence in all my endeavors. Thank you for the trust you have placed in me by conveying this subject. You have always been attentive and available, showing unwavering support. I am immensely grateful for the time and sacrifices you have made at the expense of your work and obligations, as well as for your tireless encouragement, wise advice, and outstanding feedback. This work is a testament to my deep gratitude and appreciation.

To Professor OUALI IDRISSI Mariem,
my Dear Master and thesis Judge,
Professor of Radiology
at the Mohammed VI University Hospital of Marrakesh,

We are deeply moved by the enthusiasm with which you agreed to be part of our esteemed committee. Your professional journey, undeniable expertise, and personal qualities establish you as a distinguished professor and serve as an inspiration to us. Your strong character and the way you treat your students as if they were your own children truly exemplify your dedication to education. Through this work, please allow me to present a testament to my profound respect and to express my sincere gratitude

To Professor EL AMRANI Moulay Driss,
my Dear Master and thesis Judge,
Professor of Anatomy, and Plastic and Reconstructive Surgery
at Mohammed VI University Hospital of Marrakesh,

It is a privilege to recognize you as one of the foremost anatomy professors of our time. Your way of explaining complex concepts is truly the smoothest and most enlightening. It is with immense gratitude that I acknowledge your contribution to my thesis committee. My experience in your department was invaluable; beyond the medical insights gained during visits, I learned the essence of teamwork and the profound responsibility we as students hold towards our patients. Your integrity, benevolence, and generosity have been a constant source of motivation, inspiring me to strive for excellence. This work stands as a testament to your impactful guidance.

ABREVIATIONS

LIST OF ABBREVIATIONS

AI	: Artificial intelligence
AGI	: Artificial general intelligence
ANN	: Artificial Neural Network
RGB	: Red, Green, Blue
MBD	: Medical Big Data
NLP	: Natural language processing
CV	: Computer vision
HER	: Electronic health record
IoMT	: Internet of medical things
MRI	: Magnetic resonance imaging
FHIR	: Fast healthcare interoperability resources
HIPAA	: Health insurance portability and accountability
ML	: Machine learning
DL	: Deep learning
AIM	: Artificial intelligence in medicine
ALS	: Amyotrophic lateral sclerosis
CNN	: Convolutional neural networks
COREQ	: Consolidated criteria for reporting qualitative research
IRB	: Institutional review board
N	: Number of participants
P	: Participant
PTSD	: Post-traumatic stress disorder
CBT	: Cognitive behavioral therapy
COPD	: Chronic obstructive pulmonary disease
AOM	: Acute otitis media
ECG	: Electrocardiogram

LVEF : Left ventricular ejection fraction

Afib : Atrial fibrillation

FEV : Forced expiratory volume

FVC : Forced vital capacity

MONAI : Medical open network for AI

FDA : Food and drug administration

AiCE : Advanced intelligent clear-IQ engine

AR : Advanced Reality

ARDA : Automated retinal disease assessment

WHO : World Health Organization

GDP : Gross domestic product

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OUTLINE

INTRODUCTION

I. Context and Purpose of the Study:

We are at a pivotal phase in our time, marked by a digital revolution that promises to transform all aspects of our society. This evolution evokes both dreams of innovation and legitimate fears. Therefore, it is essential to approach these issues with a balanced and authentic perspective, without being overwhelmed by idealizations or excessive apprehensions. It is in this light that we will explore the theme of artificial intelligence (AI) in the healthcare sector, particularly focusing on its integration into medical practice.

Recent advancements in this field have allowed it to showcase its potential and have sparked global interest. This is evident in the rapidly increasing number of publications on the subject, as seen on platforms like PubMed® and other academic sources, reflecting a growing curiosity and investment in AI technologies[1].

Today, society is witnessing the emergence of innovative tools that utilize complex forms of AI, yielding promising results across various sectors. From healthcare and finance to education and transportation, these applications are not only enhancing efficiency but also transforming the way we interact with technology. As we explore this dynamic landscape, it becomes clear that AI is not just a fleeting trend; it is poised to redefine our future in profound ways.

AI has made remarkable strides in recent years, driven primarily by two key factors. First, the growth of Big Data has transformed the landscape, significantly enhancing both the volume and quality of collected information, along with improvements in storage capabilities. Second, the increase in processing power of modern processors has opened new opportunities for innovation. Together, these developments have brought 'Machine Learning' and 'Deep Learning' out of research labs and into real-world applications[2].

Today, AI stands as a transformative technology with tangible applications, revolutionizing various aspects of medical practice. As we look ahead, the exponential growth of AI appears inevitable, fueled by ongoing advancements in computational technologies. This momentum promises not only to refine existing applications but also to inspire entirely new paradigms in our approach to healthcare and beyond. The potential of AI is not just theoretical; it is actively

reshaping our reality and paving the way for a future where intelligent systems enhance human capabilities and improve quality of life.

The development of AI generates ambivalent feelings among physicians. It is both a source of fascination and hope, as well as a cause for concern. As progress continues and boundaries expand, many physicians find themselves questioning, feeling perplexed, or even fearful about developments for which they have not been prepared and that seem to elude them. This technology remains relatively uncommon in daily practice, and physicians' knowledge of it is generally quite limited.

This study comprised two main components. The first was a survey targeting physicians to assess their perceptions on the integration of artificial intelligence in medical practice and the second component involved conducting interviews with patients to understand their point of view on AI and how they believe it impacts their experiences and outcomes. Together, these two components provide a comprehensive understanding of the potential role of AI in the medical landscape.

The primary aim of this investigation was to assess the degree of support among physicians for the integration of artificial intelligence technology into their practice and to evaluate their expectations and concerns regarding its potential benefits and challenges. It also aimed to investigate their readiness to adopt AI tools in daily clinical practice and their preferences for specific AI applications. Furthermore, the study sought to identify any barriers or obstacles hindering the widespread adoption of AI, particularly in the Moroccan context, and to propose strategies to address these challenges.

The secondary aim was to explore the primary hopes and concerns of the Moroccan population regarding this advancement. This component sought to uncover the expectations people hold about AI's potential while also addressing their apprehensions and fears, particularly concerning issues of privacy, safety, and the impact on the physician-patient relationship. By understanding these perspectives, the study aims to bridge the gap between technological advancements and public sentiment, ensuring that AI integration aligns with the values and needs of the community.

By examining the perspectives of both physicians and patients, we will illuminate the interplay between the expectations of medical professionals, who are tasked with integrating AI into their practice, and the hopes and concerns of patients who experience these technologies firsthand. Such a holistic approach will not only highlight potential synergies but also reveal areas of tension that need to be addressed.

II. Definition of AI:

Intelligence can be loosely defined as the capability to obtain knowledge and skills and to apply those to various situations without supervision. As is the case with children, intelligence is often linked to learning. As a child grows, they learn from the parents, siblings, teachers, friends and society in general as well as how they interact with their environment. While some learning is taught, other skills are acquired and developed by a child through observation[3]. Even though intelligence is a commonly explored concept, it remains without a clear definition, as it includes a range of abilities that can differ greatly depending on the context.

Artificial intelligence (AI) is defined in comparison to human intelligence. Marvin Minsky, an American cognitive, computer scientist and one of the pioneers of AI, defined it as follows: "the science of making machines do things that would require intelligence if done by men"[4].

It is therefore essential to understand what intelligence represents in this field. Nilsson, another pioneer of AI, offers this definition of intelligence[5]: "what enables an entity to act appropriately and with foresight toward a goal." To distinguish itself from a mere tool, a machine would need to be capable of independently judging what is appropriate and perceiving or defining its own goals.

Machines are traditionally known to follow strict instructions, but now they are designed to ‘think’ and have the capability to perform tasks by learning. The branch of science and technology devoted to the creation of machines that learn and reason as intelligently as human beings is known as Artificial Intelligence, or AI. According to the father of Artificial Intelligence, John McCarthy, AI is “the science and engineering of making intelligent machines, especially intelligent computer programs”[3].

The core idea of Artificial Intelligence (AI) is to develop machines that can process data intelligently, similar to humans. It is designed to acquire knowledge or awareness from its environment, circumstances, and entities by learning[6]. AI aims to make computers, robots, or machines operate like a smart human would. Essentially, it replicates the processes of human reasoning, learning, decision-making, and problem-solving, leading to the creation of advanced software systems[3].

1. The need for AI:

The rapid advancement of technology has transformed various aspects of our lives, with artificial intelligence (AI) leading this revolution. The need for AI comes from its unparalleled ability to process and analyze vast amounts of data with speed and precision, far exceeding human capabilities. In an era where data is generated at an unprecedented rate, AI's capacity to analyze through this information to extract meaningful insights is invaluable[7].

Moreover, AI addresses the growing demand for automation in both professional and everyday settings. By automating repetitive and mundane tasks, AI not only enhances productivity but also frees up human workers to focus on more complex and creative endeavors[7].

The integration of artificial intelligence (AI) in medical practice is driven by the urgent need to address several challenges faced by healthcare systems worldwide. One major issue is the increasing demand for healthcare services due to an aging population and the rising prevalence of chronic diseases[8].

Additionally, many countries including Morocco, are experiencing a significant shortage of physicians, creating a gap between the supply of and demand, which can lead to burnout and decreased quality of care.

AI has the potential to alleviate some of this pressure by automating routine tasks, such as data entry and appointment scheduling. This allows physicians to focus more on direct patient care, reducing the cognitive load and enhancing overall efficiency. By streamlining these processes, AI not only supports healthcare professionals but also improves patient experience[9].

Furthermore, healthcare systems are under constant pressure to reduce costs while maintaining high standards of care. AI can contribute to cost reduction by optimizing administrative workflows, minimizing medical errors, and improving the management of chronic conditions. As AI continues to evolve, its role in enhancing healthcare delivery and efficiency becomes increasingly vital[9].

2. The types of AI:

As these technologies evolve, our understanding of AI continues to shift, leading to variations in categories and terminology, but they can generally be understood through the lenses of AI capabilities and functionalities[10].

Artificial intelligence (AI) can be categorized in two significant ways: based on capabilities and based on functionalities.

- **Based on Capabilities:**
  - **Narrow AI:**

Artificial Narrow Intelligence, also known as Weak AI, is the only type of AI that exists today. Any other form of AI is theoretical. It can be trained to perform a single or narrow task, often far faster and better than a human mind can[10].

OpenAI's ChatGPT® is considered a form of Narrow AI because it's limited to the single task of text-based chat.

  - **General AI:**

Artificial General Intelligence (AGI), also known as Strong AI, is today nothing more than a theoretical concept. AGI can use previous learnings and skills to accomplish new tasks in a different context without the need for human beings to train the underlying models. This ability allows AGI to learn and perform any intellectual task that a human being can[10].

  - **Super AI:**

Super AI is commonly referred to as artificial superintelligence and, like AGI, is strictly theoretical. If ever realized, Super AI would think, reason, learn, make judgements and possess cognitive abilities that surpass those of human beings[10].

- **Based on Functionalities:**
  - **Reactive Machines**:

Reactive machines are AI systems with no memory and are designed to perform a very specific task. Since they can't recollect previous outcomes or decisions, they only work with presently available data[10].

Example: Streaming and Social Media Apps Recommendation Engine: Viewing recommendations are powered by models that process data sets collected from users' viewing history to provide customers with content they are most likely to enjoy.

- **Limited Memory:**

This type of AI includes systems that can learn from historical data and improve their performance over time. They retain information for a limited time but do not possess a full understanding of past contexts[10].

Example: Generative AI tools such as ChatGPT relying on limited memory AI capabilities to predict the next word, phrase or visual element within the content it's generating.

- **Theory of Mind and Self-Aware AI:**

The last two types are theories surrounding advanced AI including two key concepts: Theory of Mind AI, which envisions machines understanding human emotions, beliefs, and intentions for more natural interactions, and Self-Aware AI, a theoretical notion of machines possessing self-awareness and consciousness. While both remain largely speculative and absent in current technology, their potential development could enable complex social intelligence and deeper interactions.

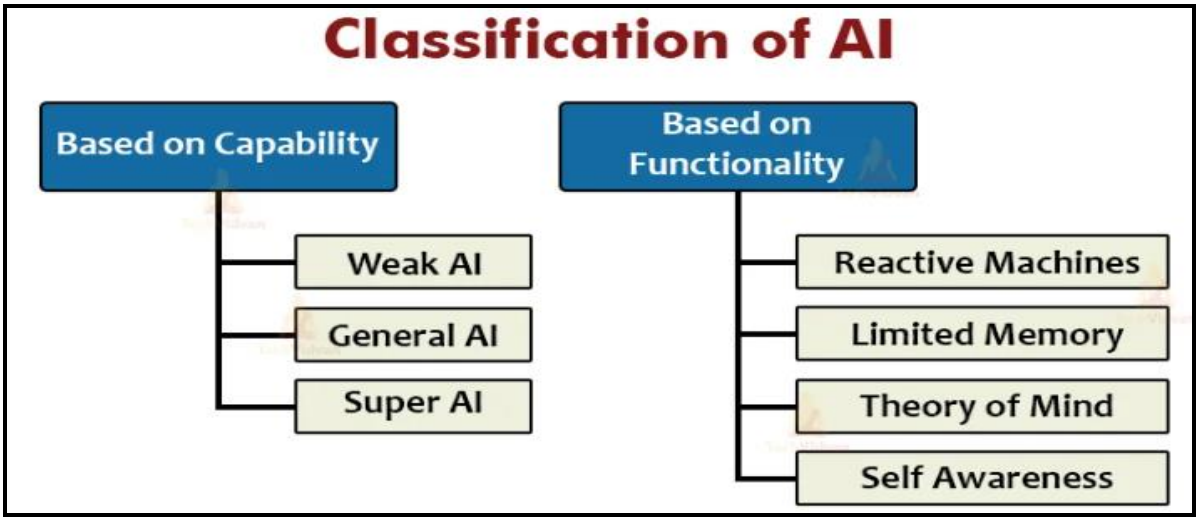

Figure (1): Types of artificial intelligence[11].

III. AI fundamentals:

1. Artificial Neural Network:

Artificial neural networks serve as the foundational framework for many AI algorithms, acting as the skeleton upon which various AI programs or models are built[12].

It is modeled after the structure and function of the human brain. It consists of interconnected nodes, or artificial neurons, organized in layers. Each neuron receives input signals, processes them using activation functions, and passes the result to the next layer of neurons. Through a process called training, neural networks learn from example data to recognize patterns and relationships, enabling them to make predictions or decisions on new, unseen data[12].

To clarify, neural networks consist of three primary layers:

1. **Input Layer**: Receives the initial data.
2. **Hidden Layers**: Intermediate layers where computations are performed.
3. **Output Layer**: Produces the final result.

For example, consider a neural network designed to classify images of animals. In the training phase, the network is provided with a large dataset of labeled images, where each image is associated with a specific animal label (e.g., cat, dog, bird).[13] The network learns to recognize features such as shapes, textures, and colors that distinguish one animal from

another. These features are extracted through multiple layers of operations in a neural network, a process commonly referred to as machine learning.

2. Machine learning:

Machine learning focuses on developing models by training algorithms to make predictions or decisions based on specific data, which, in our example, are the features of animals. It includes a variety of training techniques that allow these models to learn and draw conclusions. Different machine learning algorithms are suited to different types of datasets, such as image recognition in this example[14].

As the network processes more examples, additional hidden layers are added, allowing it to adjust the connections between neurons and improve its accuracy in classifying images. Once trained, the neural network can accurately identify animals in new images it has not encountered before, demonstrating its ability to generalize the patterns learned from the training data. This process is referred to as deep learning.

3. Deep learning:

Deep learning is a subset of machine learning that uses multilayered neural networks, called deep neural networks, which more closely simulate the complex decision-making power of the human brain. Deep neural networks include an input layer, at least three but usually hundreds of hidden layers, and an output layer, unlike neural networks used in traditional machine learning models, which typically have only one or two hidden layers[15].

Unlike machine learning, these multiple layers enable both supervised and unsupervised learning: they can automate the extraction of features from large, unlabeled, and unstructured datasets and make their own predictions about what the data represents. This capability enables fast and accurate identification of complex patterns and relationships in large amounts of data. Various forms of deep learning power most current artificial intelligence applications[16].

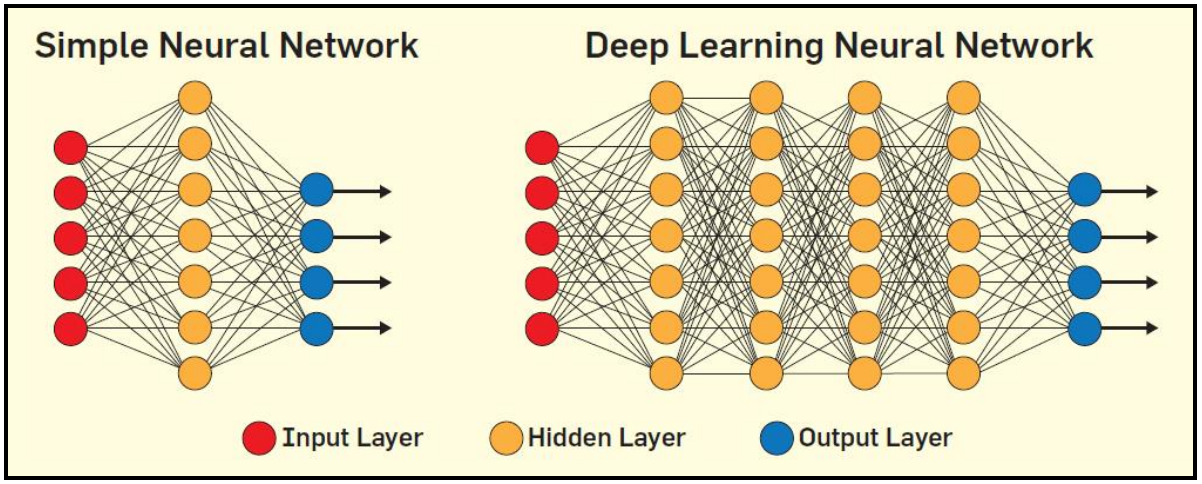

Figure (2): Difference between simple neural network and deep learning neural network[17].

An example of AI using feature extraction on a kangaroo image:

A program sees images as individual picture elements (pixels). Each color pixel is represented by numbers indicating the intensity of Red, Green, and Blue (RGB). The program recognizes a kangaroo, for example, by analyzing the patterns of pixels using mathematical algorithms.

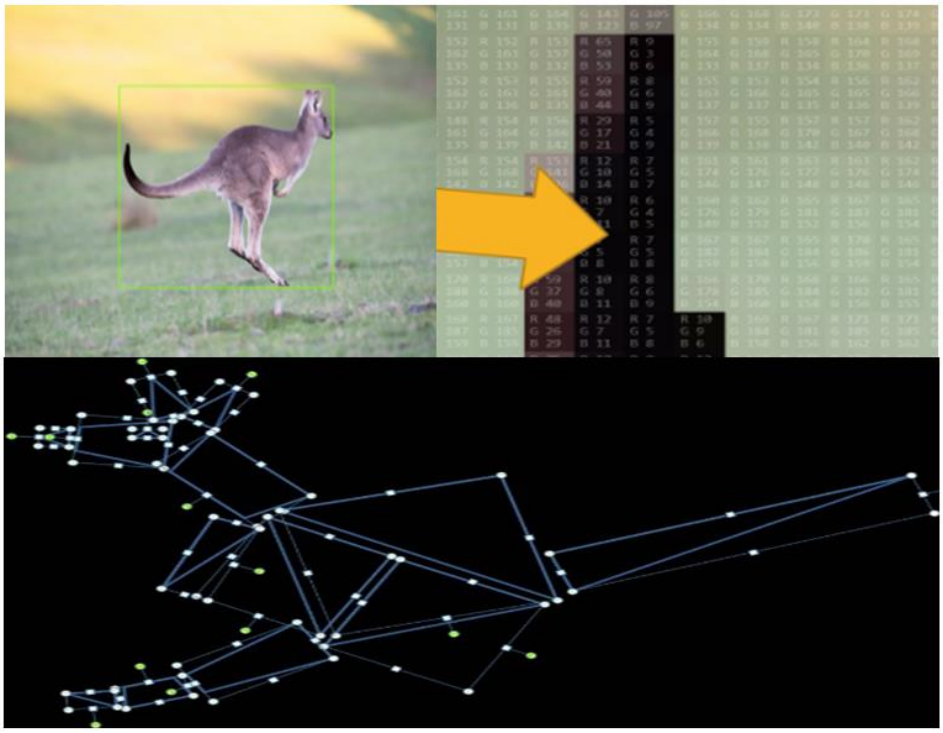

Figure (3): AI image recognition using feature extraction on a kangaroo image[13].

4. Natural Language Processing and Computer Vision:

Lastly, **Natural Language Processing (NLP) and Computer Vision (CV)** are two key fields in artificial intelligence. NLP enables programs to comprehend, interpret, and generate human language, much like how a person understands spoken words and contextualizes their meanings. Similarly, Computer Vision teaches machines to analyze and interpret visual information, akin to how humans perceive and recognize objects and scenes. Together, these disciplines significantly enhance human-computer interaction by enabling machines to process and respond to both textual and visual data effectively[18].

The Brain of Artificial Intelligence: An Analogy for Understanding AI Systems:

Before we delve further into AI, it's helpful to explain the entire system using an analogy for better understanding:

The model or program functions like the brain; it serves as the framework that encompasses the entire system. A neural network, composed of interconnected nodes, collaborates to process information, acting like neurons that form the brain's skeleton and, in this context, the program's structure.

The algorithm functions as a method of reasoning, similar to how a teacher guides and instructs a student in problem-solving. Developers integrate algorithms into the program to define how it learns from data and directs its decision-making process. Big Data serves as a vast reservoir of information and knowledge acquired over time, a process known as training, which the model uses to learn and make predictions independently.

Finally, Natural Language Processing (NLP) enables the algorithm to understand and interpret textual information, akin to how a human comprehends spoken language, while Computer Vision allows it to analyze and interpret visual data, much like how a person perceives and recognizes objects in their environment. Together, these capabilities enhance the model's ability to process diverse types of information and make informed decisions.

IV. Big data:

1. Definition and Characteristics:

Big Data refers to large, complex, and rapidly growing collections of data that traditional processing software cannot handle. This data can be both structured (like spreadsheets) and unstructured (like audio data or images) [19].

In simpler terms, Big Data is the vast amount of information used to train programs and help them learn. In our previous example, it refers to the large dataset of labeled images, where each image is associated with a specific animal label.

The characteristics of Big Data can be described by the 3 Vs[19]:

1. **Volume**: Refers to the amount of data generated from various sources, often measured in terabytes or exabytes.
2. **Velocity**: Describes the speed at which data is created and needs to be processed.
3. **Variety**: Represents the diverse types and formats of data, including structured data (like databases) and unstructured data (like texts, images, and audio).

2. Medical Big Data:

Big Data has transformed data handling across various industries. One of the most notable fields experiencing significant changes due to Big Data is medicine, where it manifests as **Medical Big Data (MBD)**.

Medical Big Data refers to the vast quantities of health-related data generated from various sources, including electronic health records (EHRs), medical imaging, genomic sequencing, patient-generated data and other medical related datasets. The analysis of Medical Big Data aims to uncover patterns, trends, and insights that can improve patient care, enhance medical research, and optimize medical operations[20].

A search for MBD-related publications on Web of Science shows that the number of publications has increased every year since 2000. (Years 2021 and 2022 were excluded from the search since the related publications have not yet been fully indexed in the Web of Science.)[21]

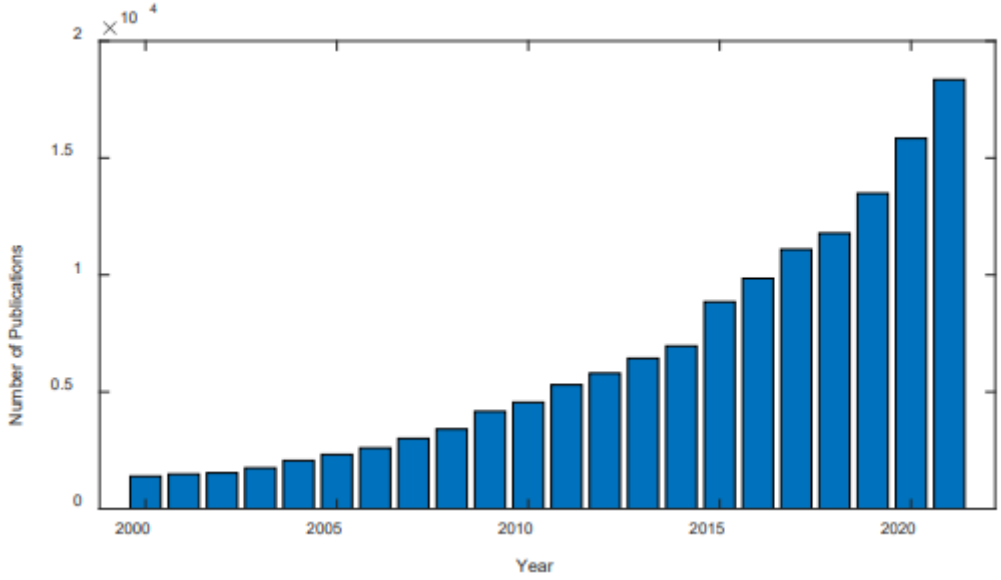

Figure (4): The number of MBD-related publications per year[21].

Medical Big Data (MBD) has the potential to significantly enhance various aspects of the medical field. It encompasses a vast collection of medical datasets, extending beyond clinical insights to include semiological and pathology data, as well as a wide range of patient records, such as:

- X-rays
- CT scans
- MRI scans
- Ultrasound scans
- Data from the Internet of Medical Things (IoMT)
- Electronic healthcare records
- Medical and medication histories

The growth of MBD, alongside the expansion of computational models, has significantly aided researchers and practitioners in data analysis. Emerging technologies are expected to further enhance MBD's role in data collection and processing, establishing it as a pivotal tool for medical practice in the future[21].

3. Technologies and tools for managing MBD:

- **Data Storage Solutions:**

Managing medical big data requires robust storage solutions. **Cloud Storage** services offer scalable options to store vast amounts of data securely over the internet[22]. These services are like renting digital space where data can be safely kept and easily accessed from anywhere.

- **Data Processing Frameworks**:

To handle and analyze the large volumes of medical data, powerful data processing frameworks are essential. This type of framework that allows distributed storage and processing of big data by dividing tasks among multiple programs, making it manageable and efficient[21].

- **Data Integration and Interoperability Tools**:

Ensuring different healthcare systems can communicate and share data effectively is vital. **Interoperability Standards** such as FHIR (Fast Healthcare Interoperability Resources)[23], facilitate this by providing common formats and rules for data exchange. These standards act like universal languages that different systems use to understand and process information consistently.

- **Data Privacy and Security Technologies**:

Protecting sensitive medical data is critical. **Encryption** ensures that data is encoded and can only be accessed by authorized users, much like securing a vault with a key. This helps protect patient privacy and complies with regulations such as HIPAA (Health Insurance Portability and Accountability Act)[24].

Access Control technologies, including role-based access and multi-factor authentication, manage who can access specific data, ensuring that only authorized personnel have access to sensitive information. This helps prevent unauthorized access and data breaches[25].

V. History of AI in medicine:

To appreciate the role of artificial intelligence (AI) in modern medicine, it is important to look at its historical journey. The development of AI in healthcare has been marked by significant milestones, starting from early theoretical frameworks to sophisticated applications that now play a critical role in medical diagnostics and treatment[26].

This historical overview will trace the key advancements and technological innovations that have contributed to the integration of AI in medicine, providing a foundation for understanding its current impact and future potential[26].

1. Early Pioneers and Technologies

Artificial intelligence (AI) was first introduced in **1950**, but early models had many limitations that made it difficult to use in medicine. By the early **2000**s, advances in deep learning helped overcome these problems. Now, AI systems can handle complex tasks and learn from data on their own. This progress marks a new era in medicine, where AI can improve clinical practice by providing better risk assessments, enhancing diagnostic accuracy, and streamlining workflows. We offer a brief look at how AI has developed over the years and how it is being used in medical practice today.

The idea of using computers to mimic intelligent behavior and critical thinking was first introduced by **Alan Turing** in **1950**[27]. In his work *Computers and Intelligence*, Turing proposed a straightforward test, now known as the "Turing Test," to evaluate whether a computer could exhibit human-like intelligence. Six years later, **John McCarthy** coined the term "artificial intelligence" (AI), defining it as "the science and engineering of creating intelligent machines"[28].

Initially, AI was based on simple "if, then" rules. Over the decades, it has evolved to incorporate more sophisticated algorithms that emulate the workings of the human brain. AI now encompasses various subfields, including machine learning (ML), deep learning (DL), and computer vision (CV).

Figure (5): Portrait of Alan Turing [29]

Figure (6) : Professor John McCarthy showing off computer chess in 1966[30].

2. Major Breakthroughs:

2.1 From the 1950s to 1970s

Early AI was focused on the development of machines that had the ability to make inferences or decisions that previously only a human could make. The first industrial **robot arm Unimate** in 1961. A few years later (1964), **Eliza** was introduced by Joseph Weizenbaum using Natural language processing, serving as the framework for future chatterbots[29].

In 1966, **Shakey**, "**the first electronic person**," was developed. Created at Stanford Research Institute, this was the first mobile robot to be able to interpret instructions[30].

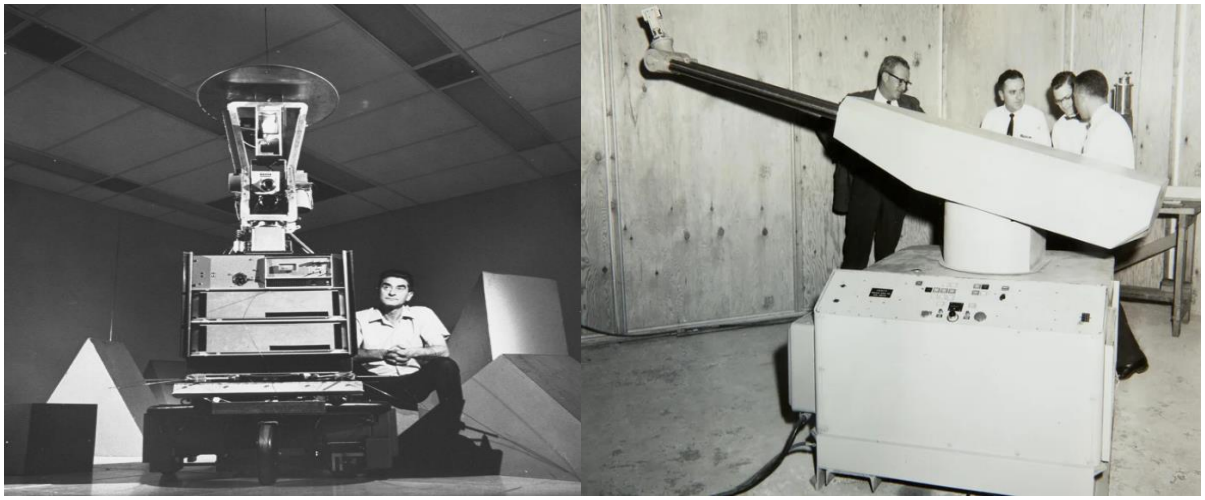

Figure (7): image of Unimate robot arm and Shakey: the first electronic person [31].

Despite these innovations in engineering, medicine was slow to adopt AI. This early period, however, was an important time for digitizing data that later served as the foundation for future growth and utilization of AIM (artificial intelligence in medicine).

The development of the Medical Literature Analysis and Retrieval System and **the web-based search engine PubMed®** by the National Library of Medicine in the **1960s** became an important digital resource for the later acceleration of biomedicine[32]. Clinical informatics databases and medical record systems were also first developed during this time and helped establish the foundation for future developments of AIM.

2.2 From the 1970s to 2000s:

Most of this period is referred to as the **"AI winter,"** signifying a period of reduced funding and interest and subsequently fewer significant developments[26]. Despite the lack of general interest during this period, collaboration among pioneers in the field of AI continued. This fostered the development of **The Research Resource on Computers in Biomedicine by Saul Amarel in 1971** at **Rutgers University**. The Stanford University Medical Experimental-Artificial Intelligence in Medicine, a time-shared computer system, was created in 1973 and enhanced networking capabilities among clinical and biomedical researchers from several institutions[26].

Largely as a result of these collaborations, the first **National Institutes of Health sponsored AIM** workshop was held at Rutgers University in **1975**. These events represent the initial collaborations among the pioneers in AIM[26].

a) The CASNET model:

One of the first prototypes to demonstrate feasibility of applying AI to medicine was the development of a **consultation program for glaucoma** using the CASNET model[33]. The CASNET model is a causal associational network that consists of 3 separate programs: model-building, consultation, and a database that was built and maintained by the collaborators. This model could apply information about a specific disease to individual patients and provide physicians with advice on patient management. It was developed at Rutgers University and was officially demonstrated at **the Academy of Ophthalmology meeting in Las Vegas, Nevada in 1976**[26].

b) MYCIN®:

A "backward chaining" AI system, **MYCIN®**, was developed in the early **1970s**. Based on patient information input by physicians and a knowledge base of about 600 rules, MYCIN® could provide a list of potential bacterial pathogens and then recommend antibiotic treatment options adjusted appropriately for a patient's body weight. MYCIN became the framework for the later rule-based system, **EMYCIN®**. INTERNIST-1 was later developed using the same framework as EMYCIN® and a larger medical knowledge base to assist the primary care physician in diagnosis[34].

c) DXplain®:

In **1986**, DXplain®, a **decision support system**, was released by the **University of Massachusetts**. This program uses inputted symptoms to generate a differential diagnosis. It also serves as an electronic medical textbook, providing detailed descriptions of diseases and additional references. When first released, DXplain was able to provide information on approximately **500 diseases**. Since then, it has expanded to over **2400 diseases**[26].

By the late **1990s**, interest in **ML** was renewed, particularly in the medical world, which along with the above technological developments set the stage for the modern era of AIM[26].

2.3 From 2000 to 2020: seminal advancements in AI:

In **2007**, **IBM developed an advanced question-answering system called Watson**, which famously won first place on the TV game show Jeopardy! in **2011**[35]. Unlike traditional systems that relied on either following data to conclusions, working backward from conclusions to data, or using simple if-then rules, Watson used a technology called **DeepQA®.**

d) DeepQA®:

This system applied natural language processing (NLP) and various search methods to analyze unstructured data and generate likely answers. It was more accessible, easier to maintain, and cost-effective compared to older systems[26].

By utilizing information from a patient's electronic medical records and other digital resources, DeepQA® technology can offer evidence-based responses in medicine. This has opened new opportunities for making clinical decisions based on solid evidence. For instance, in

2017, **Bakkar et al.** used **IBM Watson** to successfully identify **new RNA-binding proteins** associated with **amyotrophic lateral sclerosis (ALS)**[36].

e) Chatbots: Pharmabot® – Mandy® :

With advancements in computer hardware and software, digital medicine became more accessible, leading to rapid growth in AI-driven healthcare technologies. Natural language processing significantly improved chatbots, evolving them from basic communication tools like Eliza to more interactive systems. This technology was integrated into Apple's Siri in 2011 and Amazon's Alexa in 2014[26].

In **2015, Pharmabot®** was introduced as a chatbot designed to provide medication education for pediatric patients and their families, helping them understand medication schedules, dosages, and potential side effects. This tool aims to improve adherence and support for children's health management. In **2017**, **Mandy®** was developed to streamline the patient intake process in primary care settings, automating routine tasks and improving efficiency[37].

f) Convolutional Neural Networks (CNNs)

A convolutional neural network (CNN) is a type of **DL algorithm** applied to image processing that simulates the behavior of interconnected neurons of the human brain. A CNN is made up of several layers that analyze an input image to recognize patterns and create specific filters. The final outcome is produced by the combination of all features by the fully connected layers[38].

In the realm of MRI (Magnetic Resonance Imaging), **Convolutional Neural Networks (CNNs)** have introduced several key advancements. They have revolutionized the field by enhancing **image classification and detection**, improving **segmentation accuracy, and advancing image enhancement and reconstruction techniques**. These capabilities have significantly impacted diagnostic processes and image analysis, setting the stage for more detailed exploration of CNN applications in medical imaging[38].

AI has come a long way from the initial Turing test to its current avatar. As we enter the "roaring twenties," we are at the dawn of a new era in medicine when AI begins its immersion into daily clinical practice.

3. AI timeline in medicine:

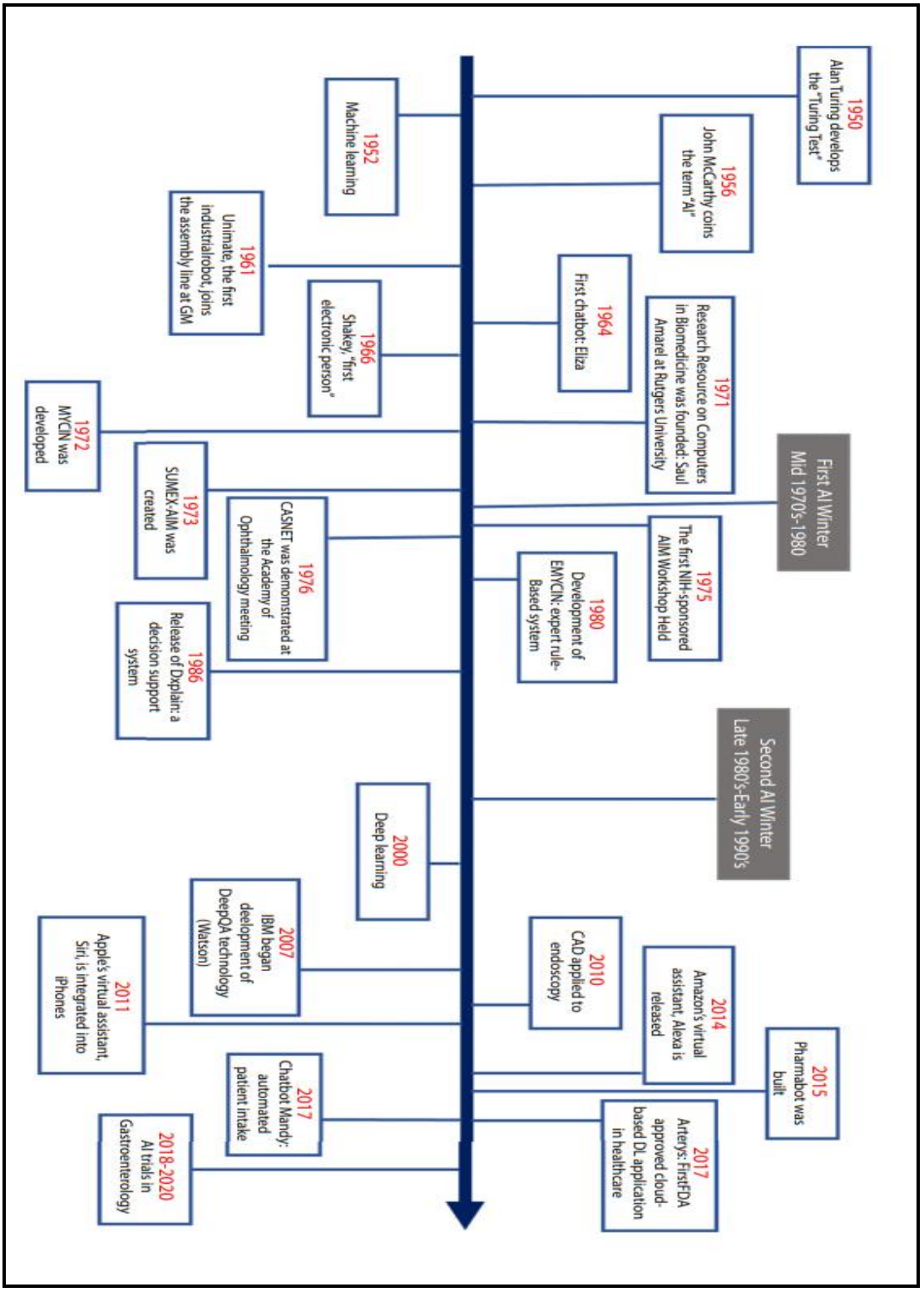

Figure (8): Timeline of the development and use of artificial intelligence in medicine[26].

MATERIALS AND METHODS

I. Physicians Survey:

1. Type of the Study:

This was a descriptive, cross-sectional quantitative study, conducted as an opinion survey, carried out between **February 01, 2024, and May 30, 2024.**

2. Study Population and Sampling:

The study examined **Internists, General practitioners, and Specialists** within the **Marrakech region**, aiming to gather comprehensive insights from a diverse group of medical professionals. By including various types of physicians, the research aimed to capture a broad range of perspectives on the integration of artificial intelligence in medical practice across different specialties and levels of expertise.

A **random sampling method** was utilized to select physicians, ensuring a representative cross-section of the medical community within the Marrakech region. This approach involved randomly choosing medical professionals from a list of internists, general practitioners, and specialists to participate in the survey. By using random sampling, the study aimed to minimize selection bias and enhance the generalizability of the findings across different types of medical practitioners.

3. Questionnaire:

a) Development:

To develop the questionnaire on the impact of AI in medical practice within the Moroccan context, we adopted a structured approach to ensure it addressed key issues and reflected a wide range of perspectives from Moroccan physicians with the goal of understanding their views on integrating AI into their practice, focusing on their perceptions of its benefits, challenges, and potential applications. We also explored their concerns about how Moroccan patients might react to AI, particularly regarding its use in their care, issues related to confidentiality, and the broader implications for the professional lives of Moroccan physicians.

The questionnaire was crafted with input from experts in both AI and healthcare, and, of course, with guidance from my supervisor, to ensure it was both relevant and well-designed.

After an initial pilot with a small group of physicians to fine-tune the questions and format, the finalized questionnaire was distributed to a diverse sample of physicians across various specialties in the Marrakech region.

b) Composition:

An online questionnaire was created **using Google Forms®** and was structured into **six** main sections:

- **Sociodemographic characteristics of physicians:**

This section presents the sociodemographic profile of the physician respondents, including age, gender, medical specialty, practice location, years of experience, and activity level. These factors are important for understanding how demographic variables may influence perceptions of AI in medical practice.

- **Factors Influencing AI Adoption in Medical Practice:**

This section explores the factors affecting AI adoption, such as physicians' computer literacy, foundational AI knowledge, current use of AI tools, and workplace access to technology. By assessing these factors, we can better understand the barriers and facilitators to AI adoption in healthcare, including technical readiness and familiarity with AI concepts.

- **Key Considerations for AI in Medical Practice:**

This section addresses key concerns physicians have regarding AI, including their confidence in AI tools, patient reactions, the physician-patient relationship, data confidentiality, and patient safety. These considerations are essential for understanding how AI may impact both clinical practice and the trust patients place in AI-driven care.

- **Top Applications and Implementation Challenges:**

This section identifies the primary AI applications physicians find most useful, such as diagnostic support and treatment planning, as well as the main challenges to implementation, such as technical limitations and financial constraints. Understanding these applications and challenges is crucial for identifying areas where AI can improve care and where more support is needed for successful integration.

- **Impact of AI on the professional lives of physicians**:

This section examines how AI affects physicians' professional roles, including concerns about job displacement, shifts in professional responsibility, and overall profession satisfaction. It provides insight into how AI adoption might reshape the physician's role and impact their day-to-day work.

- **Perspectives on AI Integration and Education in Medicine**:

This section explores physicians' views on the increasing integration of AI in medicine and their intentions to pursue further education on AI. Understanding physicians' openness to AI and their willingness to learn about it is essential for promoting continued professional development and preparing them for the evolving medical landscape.

To address the question about respondents' familiarity with computer tools, we provided clear criteria to ensure that all participants evaluated their own skills in a consistent manner.

We deliberately placed the question about respondents' support for the development of AI in medical practice at the end of the survey. This was done to allow physicians to reflect on the topic through the earlier questions before answering. We believed that this period of reflection was crucial, as this question was central to the main objective of the study.

Additionally, we included a suggestions section in the questionnaire to gather more insights from participants.

c) Distribution:

Interns, general practitioners, and specialists were invited to complete the online questionnaire. They could access it directly via a link included in the invitation email to participate in the study.

The channels used for distributing questionnaires via email included networks of substitute physicians, medical announcement websites, and the professional social network LinkedIn®. We also visited several medical offices and both public and private hospitals in Marrakech in person to distribute the questionnaire.

At the beginning of the questionnaire, we provided a brief introduction outlining its purpose and objectives to ensure participants understood the context of the study. We informed

them about the approximate time required to complete the questionnaire, which was designed to be concise and efficient. Additionally, we emphasized the confidentiality and anonymity of their responses, assuring them that their personal information would be kept secure and that their answers would be used only for research purposes. This approach was intended to build trust and encourage honest and accurate responses from the participants.

The questionnaire was available online from **February 01, 2024, to May 29, 2024,** and responses were automatically collected into an Excel® spreadsheet.

4. Data Analysis:

In this study, data analysis was conducted using Microsoft Excel®, a widely used tool for data management and statistical analysis. The initial step involved importing the dataset into Excel®, followed by thorough data cleaning to ensure the integrity of the analysis. This process included the removal of duplicate entries, and the correction of any discrepancies identified in the dataset.

To explore the relationships within the data, we utilized various Excel® functions which allowed the calculation of key statistical metrics. Pivot tables were employed to summarize and analyze the data across multiple dimensions, facilitating a deeper understanding of underlying trends.

Furthermore, we leveraged Excel's robust charting capabilities to create visual representations of the data, including bar graphs, line charts, and pie charts. These visual aids not only enhanced the presentation of the findings but also provided clear insights into the trends and patterns observed throughout the analysis.

5. Ethical Consideration:

Informed consent was obtained from all participants, with clear explanations provided about the study's purpose and procedures. Participants' privacy was safeguarded through data anonymization techniques, ensuring that individual responses could not be traced back to them. The survey design respected the professional autonomy of the physicians, allowing them the option to withdraw at any time without consequence.

These measures ensured that the study gathered valuable insights while upholding the rights of all participants involved.

6. Conflict of Interest:

There were no conflicts of interest to declare.

II. Moroccan Patients Interview:

1. Type of the Study:

To better understand the hopes and worries that Moroccan citizens have about the rise of artificial intelligence in medical practice, we carried out a qualitative study through semi-structured interviews. This approach allowed us to delve into the personal insights and feelings of individuals, capturing their unique perspectives.

Qualitative research is particularly valuable for exploring subjective experiences, as it focuses on understanding emotions, thoughts, and behaviors without the need to quantify or measure them. By engaging in this dialogue, we aimed to shed light on the human side of this important issue.

2. Preliminary Research:

Before conducting the interviews, we carried out a literature review to gain the necessary skills for developing the interview guides. This step also allowed us to examine existing research and refine our research question. We kept the review focused on maintaining objectivity and avoiding any potential biases related to the study's subject. After gathering and analyzing all the study data, we revisited the literature to deepen our understanding of the concepts and advance the theories.

The bibliographic study was conducted using databases such as PubMed®, Cairn.info®, and Google Scholar®.

3. Study Population and Sampling:

In line with qualitative research methodology, we used a purposeful sampling approach, aiming for exemplarity rather than representativeness. We selected a total of 10 participants to find a good balance between maximizing the diversity of individuals and situations while

ensuring that our findings would be meaningful. We focused on a maximum variation sampling method to include a range of characteristics, such as:

- **Age**
- **Gender**
- **Socio-professional background**
- **General computer skills**

Some participants were recruited during medical consultations, while others were found through indirect networks using a snowball sampling method. This approach allowed us to gather a diverse and varied group of individuals for our study.

4. Data Collection Process:

To gather data, semi-structured interviews were conducted in Arabic dialect, allowing participants greater freedom in expressing their thoughts. The interviews were then translated, interpreted, and analyzed in English.

An interview guide was developed to cover all relevant themes, including a series of open-ended questions that encouraged prompts and rephrasing for clarity. The questions were designed to be simple, clear, and easy to understand. Rather than adhering to a rigid questionnaire format, the guide was flexible, allowing for adjustments during the conversation to facilitate a smooth flow.

Given the complexity of the subject, it was deemed essential to provide a straightforward definition of artificial intelligence, along with examples of its medical applications, to assist participants in reflecting on the topic. Creating a supportive environment for the interviews was crucial, maintaining a neutral stance and avoiding any judgment.

To ensure methodological rigor, the interview guide was crafted following the **COREQ** (COnsolidated criteria for REporting Qualitative Research) framework[39]. A pilot interview was conducted to assess the guide's relevance, with modifications made based on insights gathered from the first three interviews.

All interviews, whether conducted in person or remotely, were recorded using Audacity® software on a computer with a microphone. The ten interviews took place in **September 2024** and were transcribed verbatim using Word® software.

To protect participants' privacy, the transcripts were anonymized by assigning each participant a letter and a number: 'P' for Participant, followed by the corresponding number.

5. Data Analysis:

The interviews were subjected to analysis using **the method of "grounded theory,"** as described by **B. Glaser and A. Strauss**. This inductive approach allows for the examination of the interviews concurrently with their collection[40].

The process of theorizing involves extracting the meaning from an event, connecting various elements of a situation, and renewing our understanding of a phenomenon by presenting it in a different light. It is crucial that the results are firmly grounded in the empirical data we have gathered.

The initial stage, referred to as coding, involves analyzing the interviews concurrently with their collection.

The researcher segments the text into groups of words or verbatim excerpts, assigning a code to each based on its meaning. These codes are then organized into an Excel® spreadsheet. The researcher conducts this coding independently and ensures the validity of the findings by revisiting the codes.

The second level of coding is thematic: we identified emerging ideas and grouped them into several themes referred to as "categories." We then arranged and structured these categories according to a framework to facilitate their conceptualization.

The third and final coding level focused on developing a theoretical model. We identified possible relationships among the categories to provide a coherent response to the research question, resulting in a schematic representation that encapsulates the entire study.

Finally, when presenting our findings, the bolded codes may appear consecutively. Each box contains the corresponding verbatim excerpted linked to the code, arranged in the order they are referenced according to the following format:

Code 1, Code 2, Code 3

- **Box 1 = verbatim for Code 1**
- **Box 2 = verbatim for Code 2**
- **Box 3 = verbatim for Code 3**

When multiple quotes or verbatim excerpts are included within the same box, they correspond to the same code.

6. Ethical Consideration: (IRB approval)

This research emphasizes ethical considerations due to the sensitive nature of interviewing patients about their experiences with artificial intelligence (AI) in general, particularly in medical practice. **Institutional Review Board (IRB) approval was obtained** to ensure that the study met ethical standards for working with human subjects.

Informed consent was a key part of the process. Participants were provided with clear information about the study's purpose, procedures, and any potential risks. They were informed that they could withdraw from the study at any time without any negative consequences.

Verbal consent was obtained, allowing participants to ask questions and clarify any concerns before agreeing to take part.

I ensured confidentiality by anonymizing participants' identities and responses. Data was stored securely. Identifiable information was removed from the final analysis to protect participants' privacy.

7. Conflict of Interest:

There were no conflicts of interest to declare.

RESULTS

A. Physicians Survey

I. General Data of the Sample:

1. Age:

The age distribution of surveyed physicians plays a pivotal role in understanding their perspectives on the integration of AI in medical practice. Analyzing this demographic data reveals varying attitudes toward technology based on career stage, which can significantly influence how AI is adopted.

The following segments provide a closer look at the insights gathered from different age groups:

- **Younger Physicians (Aged 24-34):**

This group represents the largest segment of respondents, comprising **60%** of the total. Their significant representation suggests a strong openness to technological advancements. Likely influenced by recent exposure to digital innovations during their medical education and early career stages.

- **Mid-Career Physicians (Aged 35-54):**

This group consists of **26%** of the respondents. Mid-career physicians may offer a balanced viewpoint, recognizing both the opportunities and challenges that AI presents. Their insights suggest the necessity for tailored AI adoption strategies that consider the unique needs and concerns of each demographic within the medical community.

- **Senior Physicians (Aged 55 and Older):**

This demographic accounts for a combined **14%** of the survey population. Senior physicians may approach AI with greater caution, driven by concerns regarding its impact on traditional patient care models. They face challenges in adapting to new technologies and often emphasize the need to maintain the human element in medical practice.

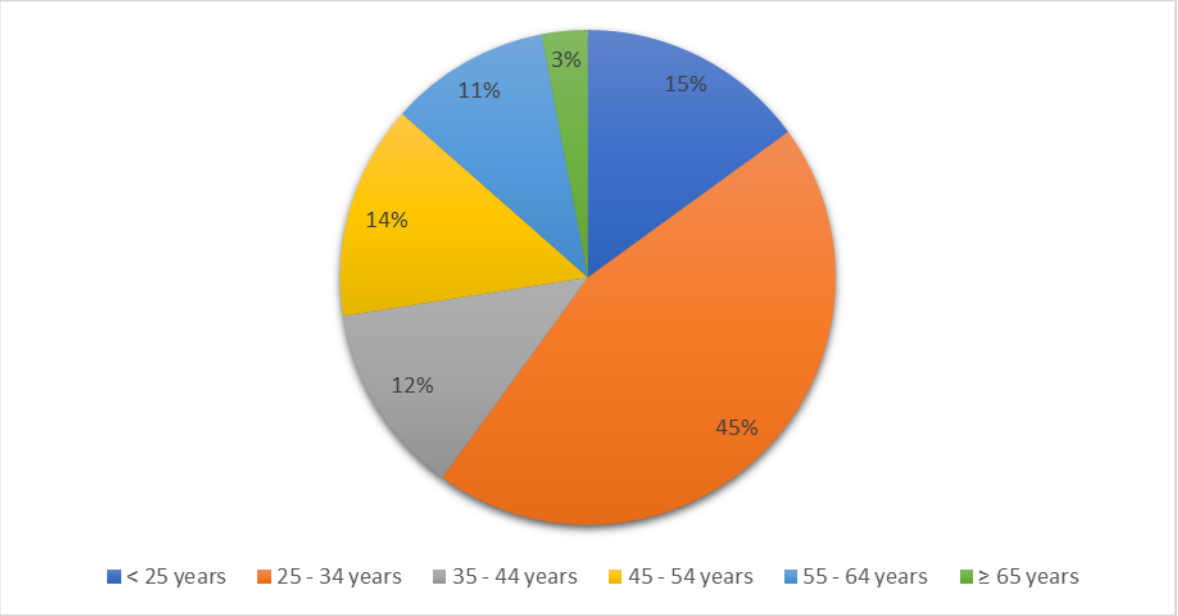

Figure (9): Age Distribution of Physicians

2. Gender:

The gender distribution among the survey respondents indicates a modest predominance of female participants. Specifically, there are **111** females, accounting for **56%** of the total respondents. In contrast, the number of male participants stands at **89**, representing **44%** of the sample. This results in a sex ratio of approximately **0.8** males for every female participant.

This reflects a notable but not overwhelming majority of females in the survey population. This distribution is reflective of the evolving demographics within the medical profession, where the proportion of female physicians is steadily increasing. Such representation enhances the survey's ability to encompass a wide spectrum of perspectives.

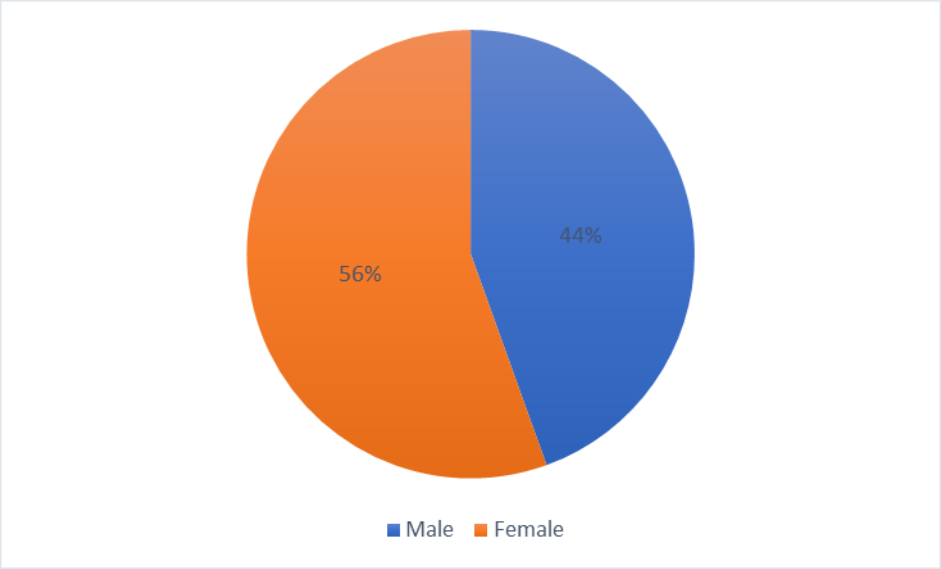

Figure (10): Gender Distribution of Physicians

3. Type of Medical Practice:

In analyzing the distribution of medical professionals within the study, we find that out of the total 200 respondents, **49%** are **General practitioners**. This significant proportion highlights the crucial role these professionals play in primary care, where they often serve as the initial point of contact for patients. Their broad-based approach to healthcare delivery is essential for understanding the dynamics of patient management and the challenges faced in general practice.

Internal physicians comprise **27%** of the respondents, offering valuable insights into the management of diverse and urgent health conditions. Their participation in the study underscores their comprehensive approach to care, which includes managing urgent cases and a wide range of diseases.

Specialist physicians constitute **24%** of the sample, bringing specialized knowledge from various medical fields. Their perspectives enrich the analysis by focusing on medical challenges and innovations. The inclusion of specialists allows for a deeper examination of how advancements in medical technology and treatment protocols are applied within specific areas.

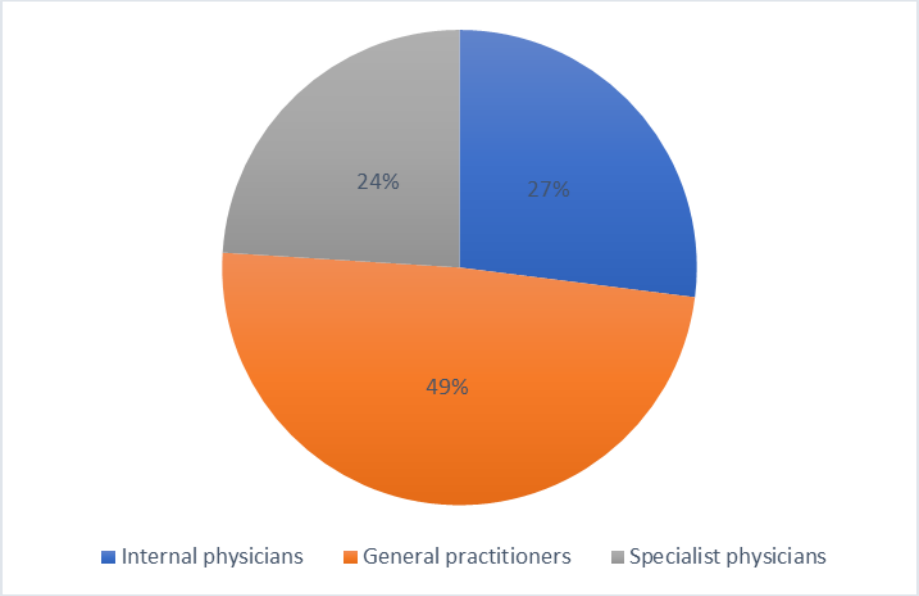

Figure (11): Types of Medical Practice Among Physicians

4. Practice Location:

The study reveals that a substantial majority of respondents, **82%**, practice in **urban areas**. This concentration of medical professionals in urban settings suggests that these regions, with their higher population densities, offer more opportunities for varied medical practices and access to advanced medical facilities. The urban environment likely provides a dynamic setting for practitioners to engage with diverse patient populations and complex medical issues.

Conversely, only **18%** of the respondents practice in **rural areas**. This lower representation underscores the ongoing challenges of medical practice accessibility in less densely populated regions. Rural practitioners often face unique obstacles, such as limited resources and a broader scope of practice due to the lack of specialized facilities. These factors can significantly impact the delivery of medical services and highlight the need for targeted strategies to support rural medical practitioners.

Together, these findings underscore the disparity in medical practice distribution between urban and rural areas. Understanding these differences is crucial for developing policies and interventions aimed at improving medical practice access and quality in rural regions while also addressing the demands of urban medical settings.

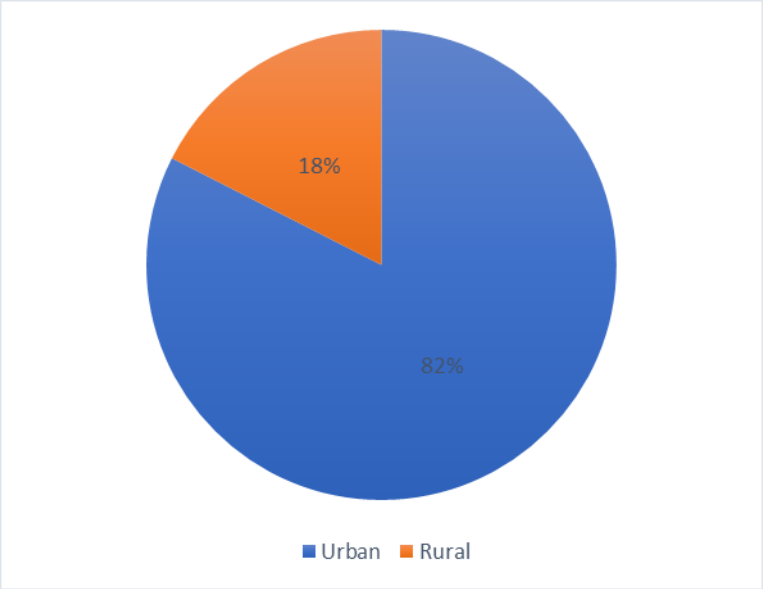

Figure (12): Practice Location Distribution of Physicians

5. Years of professional experience:

The examination of the distribution of medical practitioners according to their years since thesis completion provides important insights into the experience landscape within the medical field. The findings can be structured as follows:

- **Early Career Stage (Less than 4 years of practice):**

This group comprises **111** individuals, indicating a substantial influx of new professionals into the field. This suggests a vibrant, youthful workforce poised to bring innovative perspectives and adaptability to evolving healthcare challenges.

- **Mid-Career Stage (4 to 19 years of practice):**

Encompassing **41** practitioners, this segment reflects a stable group characterized by significant experience and ongoing professional growth. These practitioners are likely dynamic in their roles, contributing actively to the medical field.

- **Seasoned Professionals (20 to 29 years of practice):**

With **27** individuals, this group represents seasoned professionals who may hold leadership positions. They are pivotal in mentoring and developing younger colleagues, leveraging their extensive experience.

- **Experienced Experts (30 to 39 years of practice):**

This segment includes **12** practitioners who balance vast experience with the potential for continued contributions, possibly in specialized practice areas or academic roles.

- **Veteran Practitioners (>40 years of practice):**

Comprising just **4** individuals, this small group highlights those with enduring commitment and expertise, having witnessed and adapted to decades of medical advancements.

In conclusion, this distribution not only emphasizes the generational diversity within the healthcare workforce but also underscores the potential for cross-generational collaboration and knowledge transfer. Such interactions are crucial for advancing medical practice in a rapidly changing landscape.

Five participants did not provide a response to this question.

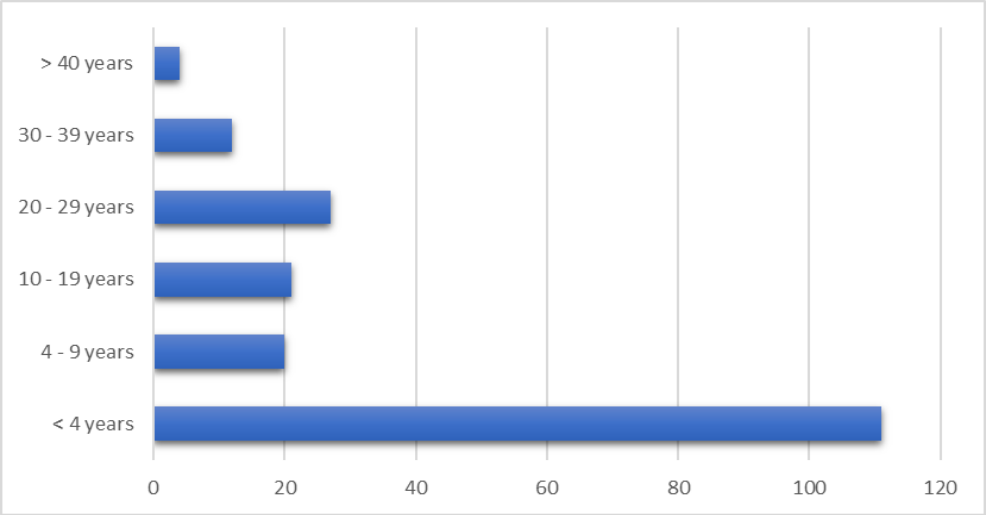

Figure (13): Years of Professional Experience of Physicians

6. Activity Level:

The analysis of consultation frequency data provides valuable insights into the workload of medical practitioners, revealing distinct patterns across different consultation brackets.

- **Moderate Consultation Range (15-50 consultations per day):**

A significant number of physicians fall within this category, with **53** physicians conducting between 15 and 30 consultations, and **54** managing between 31 and 50 consultations daily. This

suggests a balanced alignment between patient demand and physicians' capacity, potentially supporting consistent quality of care.

- **Low Consultation Range (fewer than 15 consultations per day):**

This bracket includes **49** physicians and may indicate practices that either require more time per patient, possibly due to the nature of the specialty, or are in environments with lower patient demand.

- **High Consultation Range (51-100 consultations per day):**

This group comprises **28** physicians, highlighting a substantial workload that, while indicative of strong patient demand, raises concerns about maintaining care quality and managing professional stress.

- **Very High Consultation Range (more than 100 consultations per day):**

With **9** physicians in this category, the workload is exceptionally high, suggesting the need for careful management to ensure both quality of care and practitioner well-being.

In conclusion, these distributions underscore diversity and complexity within medical practice environments. They highlight the necessity for tailored strategies to manage varying workloads effectively, ensuring the sustained well-being and performance of healthcare professionals.

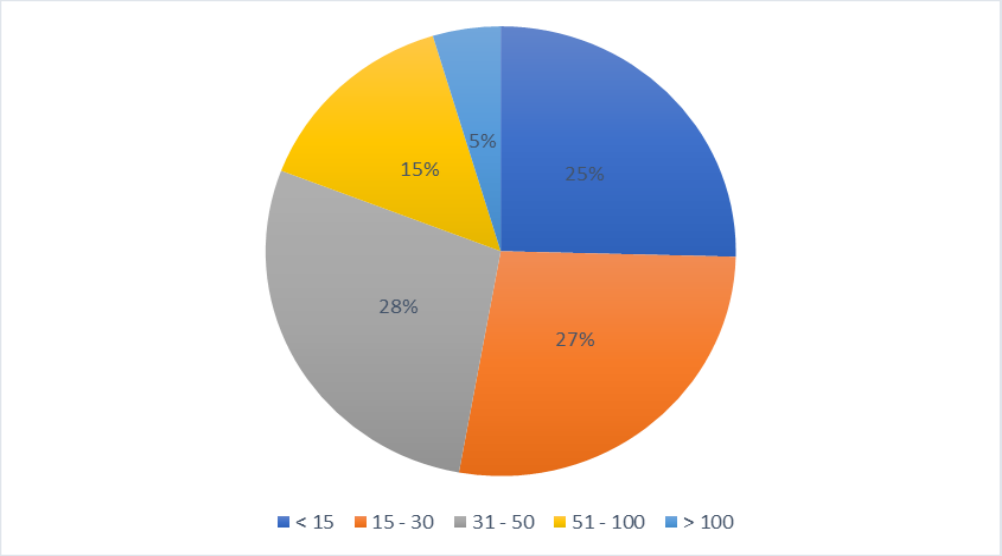

Figure (14): Activity Level of Physicians (Consultations per Day)

Table 1: Sociodemographic characteristics of physicians.

Characteristics		Total Headcount N (200)	Percentage
Age			
	< 25 years	30	15%
	25-34 years	90	45%
	35-44 years	25	12%
	45-54 years	28	14%
	55-64 years	21	11%
	>65 years	6	3%
Gender			
	Female	111	56%
	Male	89	44%
Type of Medical Practice			
	Internal physicians	54	27%
	General practitioners	98	49%
	Specialist physicians	48	24%
Practice Location			
	Urban	165	82%
	Rural	35	18%
Years of professional experience		Exception N (195)	
	< 4 years	111	57%
	4-9 years	20	10%
	10-19 years	21	11%
	20-29 years	27	14%
	30-39 years	12	6%
	> 40 years	4	2%
Activity Level			
	<15 consultations	49	25%
	15-30 consultations	53	27%
	31-50 consultations	54	28%
	51-100 consultations	28	15%
	>100 consultations	9	5%

II. Factors Influencing AI Adoption in Medical Practice:

1. Level of Computer literacy:

In this question regarding computer literacy among physicians, the survey results indicate varying levels of comfort with computer usage, which can provide insights into their readiness to engage with technology in their medical practice.

- **Overall Comfort Level**:

A total of **118** respondents, approximately **59%**, reported feeling **comfortable** using computers. This suggests a positive trend towards the integration of technology in medical practice, as comfort with digital tools is essential for efficient patient management and data handling.

- **Moderate Comfort**:

The group characterized as "**slightly comfortable**" with **56** responses, about **28%** represents a significant portion of the respondents. This indicates a potential gap in confidence and skill that may hinder the effective use of technology. Providing targeted training programs or resources could help elevate this group's proficiency, thereby enhancing overall efficiency and patient care.

- **Low Comfort Levels**:

The findings also reveal that **9** respondents, approximately **5%**, reported "**not at all comfortable**" with computers. While this number is small, it highlights a critical area that requires attention. These individuals may face challenges in adapting to increasingly digital healthcare environments, which could impact their work and the care they_provide to patients. Addressing their specific needs through personalized training or mentorship could be beneficial.

- **Very Comfortable**:

Interestingly, **17** respondents (about **9%**) rated themselves as very comfortable with computers. This group may serve as a valuable resource for peer-to-peer training or mentoring initiatives, leveraging their skills to assist others who are less confident.

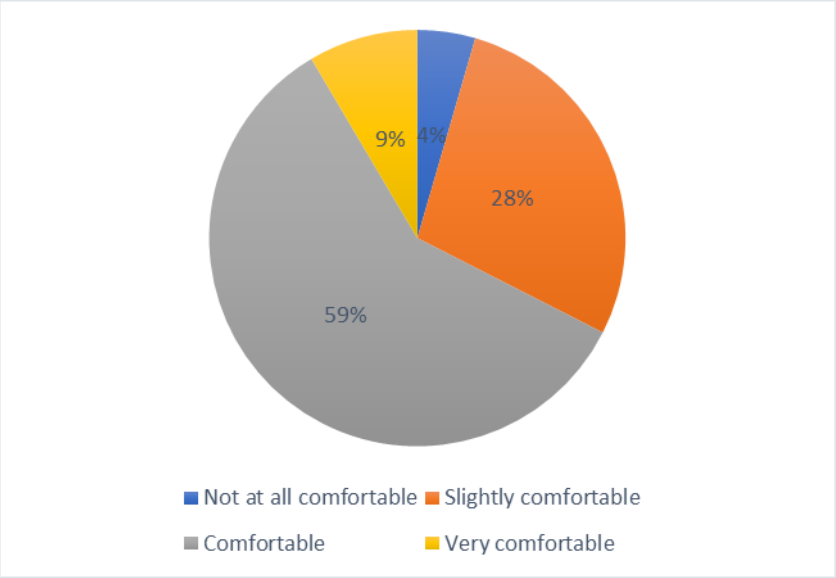

Figure (15): Distribution of Computer Literacy Comfort Levels Among Physicians

2. Workplace Computer and Internet Access:

The data on computer and internet access in the workplace provides valuable insights into the environment in which physicians operate, particularly regarding their ability to utilize AI tools effectively.

- **Permanent Access**:

A significant portion of physicians**, 80** respondents **(40%),** report having permanent access to a computer with internet connectivity. This level of access is essential for leveraging AI tools, facilitating real-time information retrieval, communication with colleagues, and utilizing telemedicine platforms. Physicians in this group are likely more comfortable integrating technology into their practice, which could enhance their use of AI applications in clinical settings.

- **Limited Access**:

However, **48** respondents **(24%)** have limited access to computers with internet connectivity. This restricted access may hinder their ability to fully utilize AI tools, as they might face challenges in conducting research, entering data, or accessing patient information. Understanding the specific limitations (e.g., time constraints, device restrictions) is important for identifying barriers to AI adoption in clinical environments.

- **No Internet Access but Computer Available:**

A total of **20 respondents (10%)** have a computer available but no internet access. This situation is concerning, as it indicates that while they have the necessary hardware, they lack the connectivity needed to engage with modern medical resources, including AI tools. This group could benefit from targeted interventions to improve internet access, thereby enhancing their ability to use digital tools in patient care.

- **No Computer at Workplace:**

Finally, **52 respondents (26%)** reported not having a computer available at their workplace. This lack of access is a significant barrier to the implementation of AI technologies, as it limits their ability to interact with digital health resources and use AI for clinical practice.

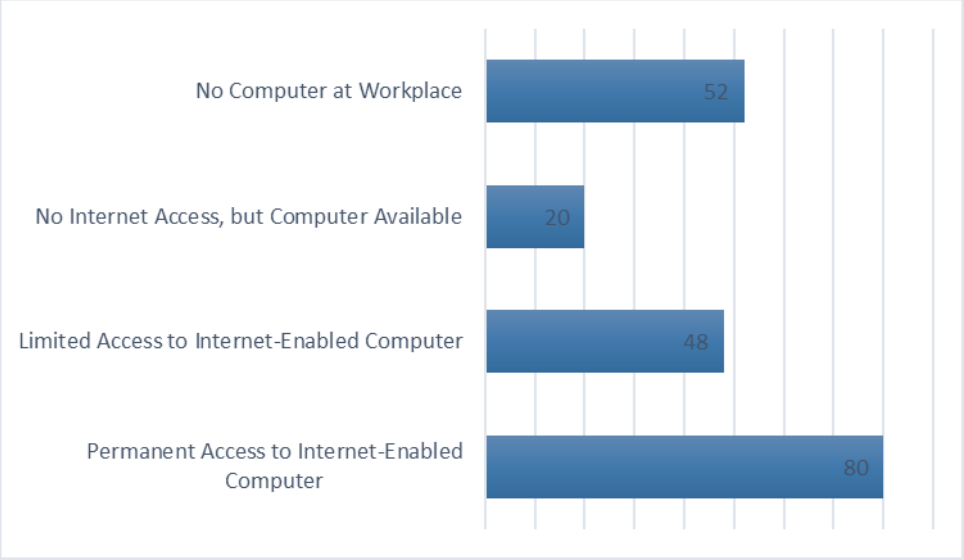

Figure (16): Access to Computers and Internet Among Physicians

3. Foundational Knowledge of AI:

The survey results regarding the perception of knowledge related to artificial intelligence (AI) technologies reveal a notable distribution among respondents.

- **Absence of Knowledge**

A substantial proportion, comprising **79 individuals or 39%** of the participants, indicated that they possess **no knowledge of AI technologies**.

This finding highlights a significant gap in understanding that may hinder the effective integration of AI within their professional practices.

- **Limited Knowledge**

In contrast, **70 respondents, accounting for 35%**, rated their knowledge as limited. This suggests that while they may have encountered concepts related to AI, their understanding is insufficient for practical application. This group represents a critical area for targeted educational initiatives to enhance their familiarity with AI technologies.

- **Moderate Engagement**

A smaller segment, consisting of **45 respondents or 23%**, reported a moderate level of knowledge. This indicates a more substantial engagement with AI concepts; however, it also suggests that only a limited number of respondents feel adequately prepared to leverage AI in their work.

- **Confidence in Knowledge**

Finally, only **6 respondents, or 3%**, consider their knowledge to be significant. This low number underscores a critical opportunity for growth, indicating that very few individuals feel confident in their understanding of AI technologies. As a result, further training and resources are necessary to foster a more knowledgeable workforce.

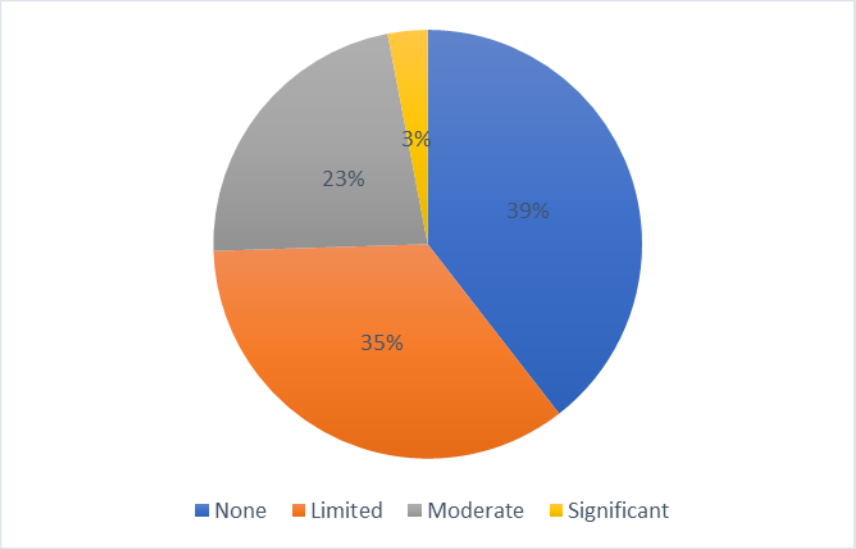

Figure (17): Distribution of AI Knowledge Levels Among Physicians

4. AI Usage and Tools Employed by Physicians:

The survey conducted aimed to assess the current use of AI technologies within medical practice. Participants were asked whether they have integrated AI technologies into their practice. The results are as follows:

A total of **129** respondents, representing approximately **64%**, confirmed the use of AI technologies in their medical practice. This demonstrates a significant adoption rate, indicating a growing trend towards the integration of advanced technologies in medical practice.

In contrast, **71** respondents, or about **36%**, indicated that they have not yet utilized AI technologies. This suggests that while there is a substantial adoption rate, some practitioners may still be hesitant or face barriers to implementing these technologies.

This data highlights the increasing role of AI in modern healthcare settings and provides a foundation for further discussion on the benefits and challenges associated with its use.

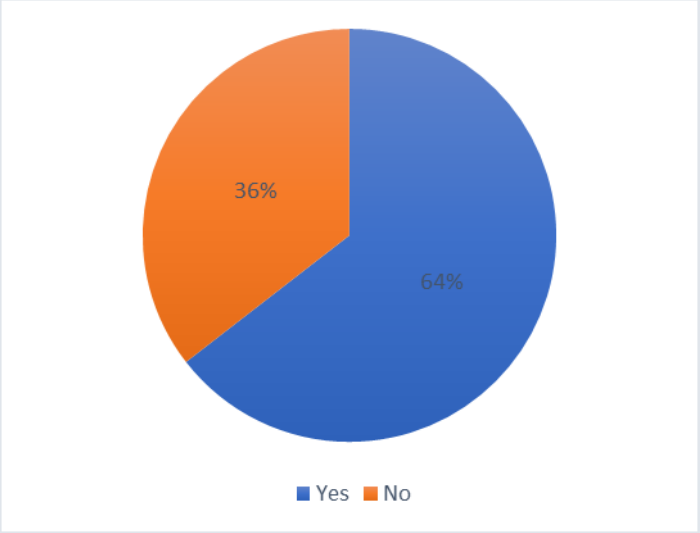

Figure (18): Adoption of AI Technologies in Medical Practice

The data on the specific AI tools used in medical practice provides valuable insights into the preferences and trends among physicians. From the **129** respondents who confirmed the use of AI technologies in their practice, **118** physicians provided detailed responses about the specific AI tools they utilize, even though they are predominantly **entry-level tools**.

- **Dominant Tools:**

ChatGPT® leads the list, with **86** physicians acknowledging its use. This suggests that conversational AI is highly valued for its potential to assist in patient communication, information synthesis, and perhaps even decision support.

PocketDoc®, with **55** physicians using it, is another popular choice, likely due to its primary applications including drug information verification and diagnostic assistance.

- **Specialized Tools:**

Vidal® (**23** physicians) and **Posos®** (**10** physicians) seem to be recognized for their specialized functions, possibly related to drug information and interactions.

Medicalcul® (**9** physicians) might be used for medical calculations, indicating a niche but critical application in clinical practice.

- **Niche and Emerging Tools:**

Tools like **Copilot®**, **Ada®**, and others mentioned by only a few physicians (ranging from **1** to **3** users each) suggest emerging interest or limited adoption in specific areas. These might include support for prescription management, ECG interpretation, or symptom checking.

The diversity of tools mentioned indicates that physicians are exploring a range of AI applications, from general-purpose AI like ChatGPT® to highly specialized software tailored for medical tasks.

The varied adoption rates reflect differences in physicians' needs and preferences, as well as the diverse functionalities offered by these tools.

Understanding the reasons behind the choice of certain tools over others could provide insights into physicians' priorities, such as ease of use, cost, integration capabilities, or specific clinical needs.

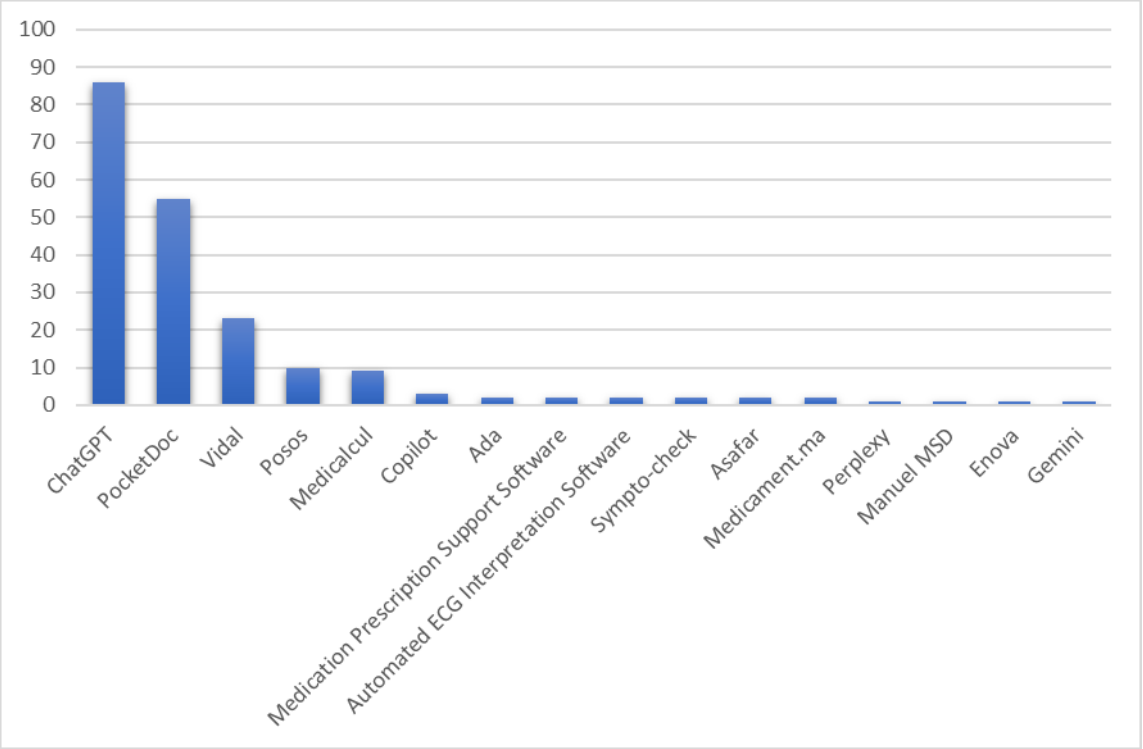

Figure (19): AI Tools Employed by Physicians in Clinical Practice.

5. Frequency of AI Usage in Daily Medical Practice:

The data collected regarding their usage of computer technology in daily medical practice reveals significant insights into the frequency of its application.

- **Rarely Usage:**

A minority of respondents, specifically **20%**, reported using AI rarely in their daily practice. This indicates a possible reliance on traditional methods or a lack of access to technological resources. The low percentage suggests that while some physicians may not prioritize technological integration, it could also highlight barriers, such as insufficient training or resources, that hinder the effective adoption of computer technology.

- **Occasional Usage:**

The largest segment of respondents, **40%**, indicated that they use AI occasionally. This suggests a moderate level of engagement with technology in clinical settings. Physicians may utilize computer systems for specific tasks, such as accessing patient records or conducting research, but may not fully integrate technology into all aspects of their practice.

- **Frequent Usage:**

A substantial portion of physicians, comprising **29%**, reported using AI frequently. This indicates a growing acceptance and reliance on technological tools in their daily practices. The frequency suggests that many physicians recognize the benefits of computer technology and raises questions about the specific applications of technology that physicians find most beneficial.

- **Consistent Usage:**

Finally, a smaller group of respondents, at **11%**, indicated that they use AI consistently in their practice. This finding may reflect a more advanced integration of technology, where physicians rely on electronic health records, telemedicine, and other digital tools as part of their routine. The lower percentage in this category underscores the need for further efforts to encourage widespread adoption of technology in medical practice.

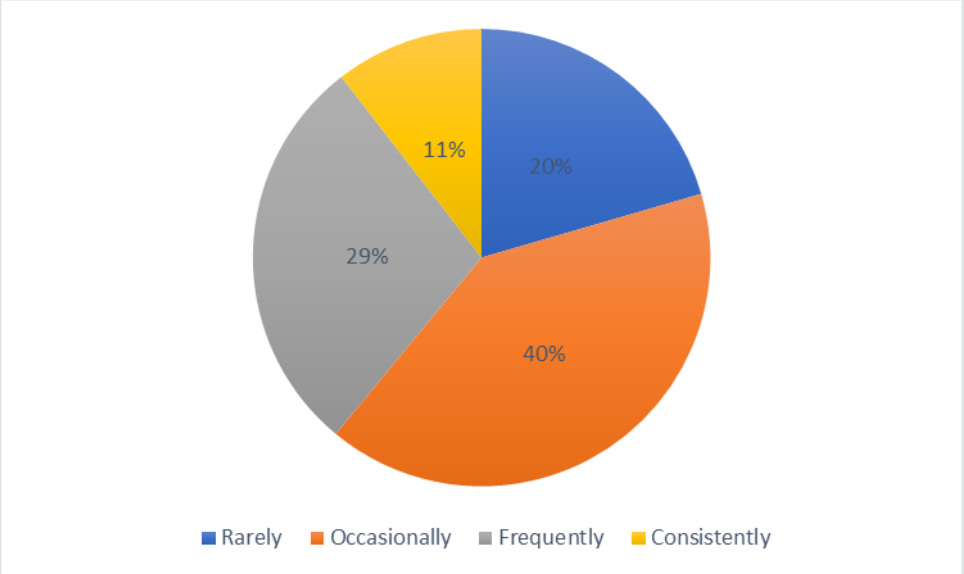

Figure (20): Frequency of Computer Technology Usage Among Physicians

Table (2): Factors Influencing AI Adoption in Medical Practice.

Characteristics		Total Headcount N (200)	Percentage
Computer literacy			
	Not at all comfortable	9	4%
	Slightly comfortable	56	28%
	Comfortable	118	59%
	Very comfortable	17	9%
Workplace Computer and Internet Access			
	Permanent Access to Internet-Enabled Computer	80	40%
	Limited Access to Internet-Enabled Computer	48	24%
	No Internet Access, but Computer Available	20	10%
	No Computer at Workplace	52	26%
Foundational Knowledge of AI			
	None	79	39%
	Limited	70	35%
	Moderate	45	23%
	Significant	6	3%
AI Usage			
	Yes	129	64%
	No	71	36%
Frequency of Usage			
	Rarely	41	20%
	Occasionally	81	40%
	Frequently	57	29%
	Consistently	21	11%

III. Key Considerations for AI in Medical Practice:

1. Confidence Levels in AI:

The survey results reflecting the confidence levels of physicians regarding AI's capacity to make medical decisions autonomously yield insightful observations.

- **Not at All Confident:**

A total of **11%** of respondents reported not at all confident in AI's ability to make autonomous medical decisions. This significant minority suggests skepticism or concern about the reliability and accuracy of AI technologies in critical healthcare settings. Possible reasons for this lack of confidence may include fears of technology's limitations, ethical implications, or past experiences that have shaped their perceptions of AI in medicine.

- **Slightly Confident:**

The largest group, comprising **37%** of respondents, expressed being slightly confident in AI's decision-making capabilities. While this indicates a general openness to the use of AI in medicine, the high percentage in this category suggests that many physicians recognize the potential benefits of AI but still have concerns about its effectiveness and the potential consequences of errors in medical judgments.

This highlights a need for further education and information on the advancements in AI technology and its applications in clinical practice.

- **Moderately Confident:**

An interesting finding is that **42%** of respondents reported being moderately confident in AI's ability to make autonomous decisions. This indicates a substantial level of acceptance and recognition of AI's potential to assist in medical decision-making. Physicians may see AI as a valuable tool that can enhance their practice while maintaining a level of caution.

- **Very Confident:**

Lastly, **10%** of respondents indicated that they are very confident in AI's decision-making abilities. This smaller percentage signifies a segment of the medical community that has

embraced the potential for AI to play a pivotal role in clinical practice. Their confidence could drive further exploration and adoption of AI solutions in clinical practice.

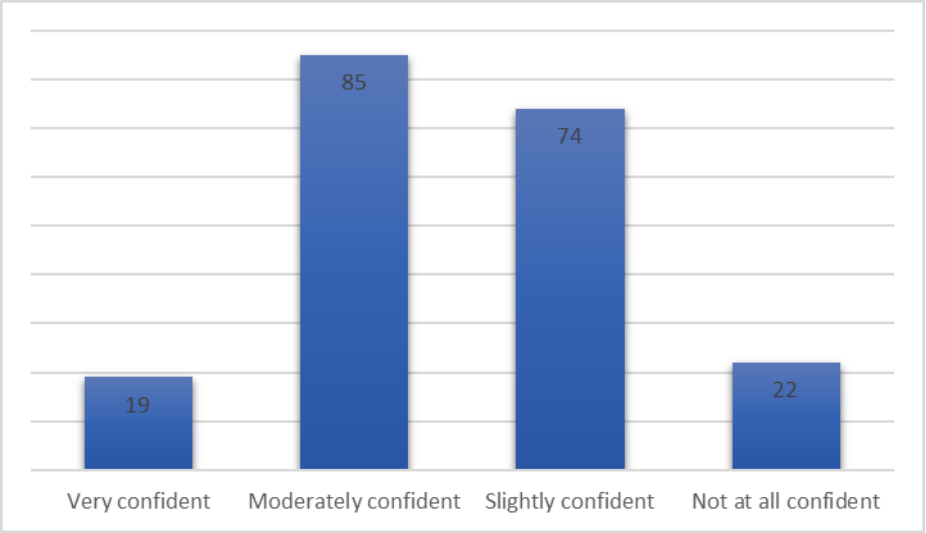

Figure (21): Confidence Levels in AI's Autonomous Decision-Making Among Physicians

2. Concerns regarding patient reactions:

Based on the survey results regarding physicians' concerns about patient reactions to the use of artificial intelligence in medical care in Morocco. The results are as follows:

- **Negative Reaction:**

Most physicians anticipate that patients may have significant concerns or skepticism about AI in healthcare, with **82** responses (**41%**) indicating negative reactions. This could stem from fears regarding data privacy, a lack of trust in technology, or a preference for traditional, human-centric care.

- **Neutral Reaction:**

A notable portion of physicians, **51** responses (**25%**), believe that patients may respond neutrally, indicating uncertainty or ambivalence about AI. This suggests that many patients might not have a strong opinion or may require more information to form one.

- **Positive Reaction:**

Some physicians are optimistic, expecting that patients may react positively, with **37** responses (**19%**) indicating acceptance, particularly recognizing the potential for improving diagnostic accuracy and efficiency in care.

- **No Opinion:**

Additionally, **30** responses (**15%**) indicate that some physicians feel patients may have no opinion on the matter, possibly reflecting a lack of awareness about AI technologies or indifference toward their implementation.

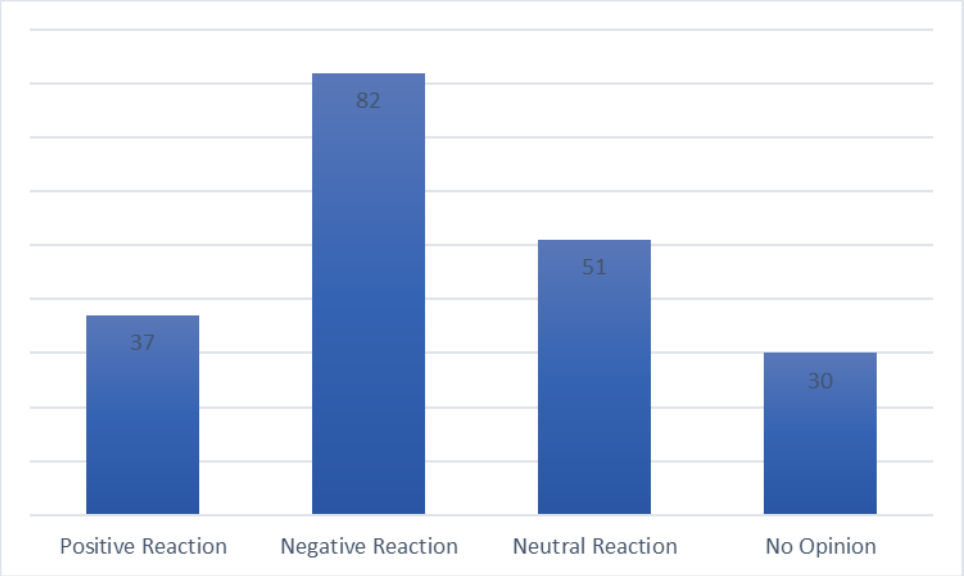

Figure (22): Concerns About Patient Reactions to AI in Medical Care in Morocco

3. Physician-patient relationship:

Based on the survey results regarding the integration of artificial intelligence (AI) and its influence on the physician-patient relationship, we can analyze the findings as follows:

- **Positive Influence:**

A total of **79** responses, representing **40%** of the respondents, indicate that many believe the integration of AI could positively influence the physician-patient relationship. This perspective may stem from the potential for AI to enhance communication, provide more accurate information, and improve patient engagement in their care.

- **Negative Influence:**

Conversely, **90** responses, accounting for **45%**, reflect concerns that the integration of AI might negatively impact the physician-patient relationship. Physicians may worry that relying on

technology could reduce important personal interactions, weakening trust and empathy essential for effective patient care. Additionally, the complexity of AI systems may confuse patients or create barriers in communication.

- **No Influence:**

A smaller group of **31** responses, or **15%,** suggests that some believe AI will have no significant influence on the physician-patient relationship. This perspective indicates skepticism about the role of technology in clinical settings or an understanding that, despite technological advancements, the core dynamic remains unchanged. These respondents may view the relationship as primarily reliant on personal interaction and the physician's ability to connect with patients on a human level.

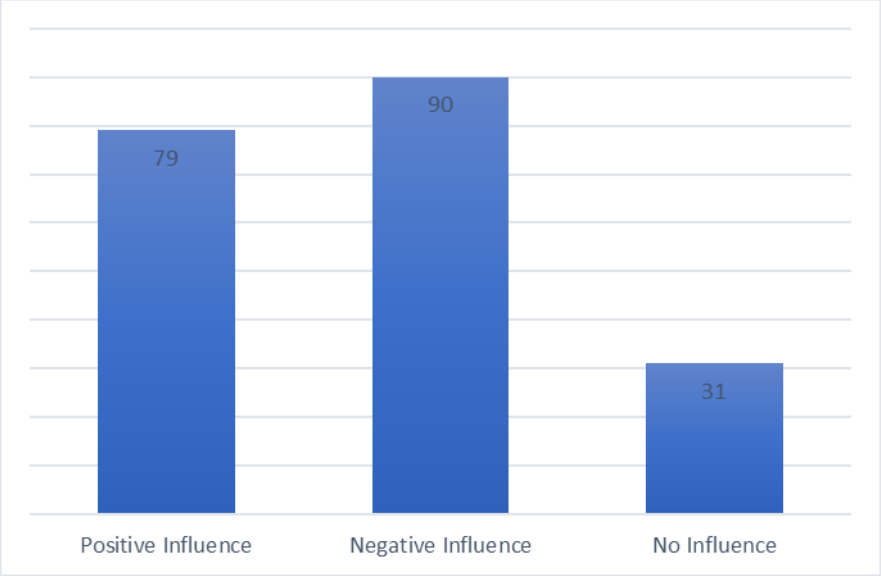

Figure (23): Perceived Influence of AI on the Physician-Patient Relationship

4. Data Confidentiality:

- **Concerns about Data Confidentiality:**

A significant majority of physicians, with **131** responses, or **65%,** express concerns regarding the confidentiality of medical data when using AI. This indicates a strong awareness of the potential risks and challenges of ensuring robust data security measures associated with data breaches and unauthorized access to sensitive patient information.

- **No Concerns:**

In contrast, **36** physicians, representing **18%,** do not have concerns about data confidentiality related to AI. This smaller group may have a higher level of trust in technology, confidence in existing data protection measures, or a belief that the benefits of AI outweigh the potential risks.

- **No Opinion:**

A total of **33** physicians, accounting for **17%,** indicated that they have no opinion on the matter. This could reflect a lack of familiarity with AI technologies, uncertainty about the implications for confidentiality, or indifference toward the issue.

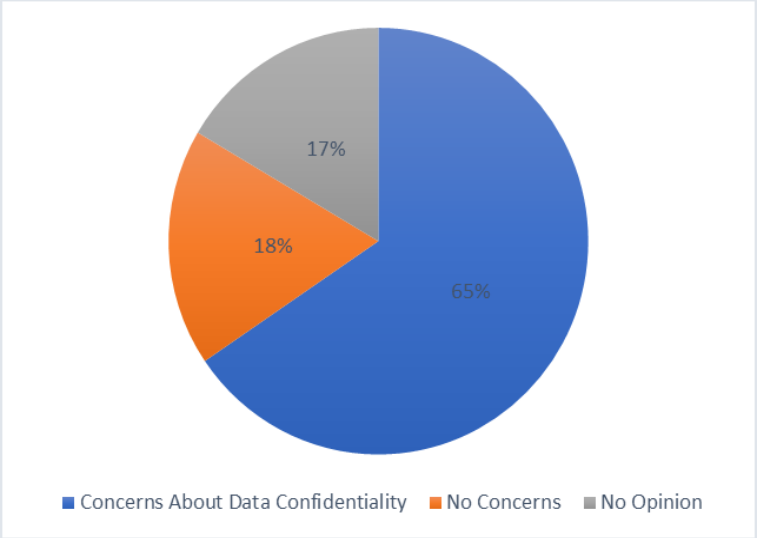

Figure (24): Concerns Regarding Medical Data Confidentiality in the Use of AI

5. Patient Safety Incidents:

Based on the survey results regarding physicians' perceptions of whether the integration of artificial intelligence (AI) will increase or decrease the risk of medical errors, the findings can be analyzed as follows:

- **Increased Risk:**

A minority of respondents, with **42** responses (**21%**), believe that the integration of AI will increase the risk of medical errors. This perspective may come from concerns about over-

reliance on technology, potential flaws in AI algorithms, or the risk of misinterpretation of AI-generated recommendations by healthcare providers.

Physicians in this group may emphasize the importance of human oversight and caution against if AI can completely replace clinical judgment.

- **Decreased Risk:**

In contrast, a substantial majority of **118** respondents (**59%**) feel that AI will decrease the risk of medical errors. This optimism likely arises from the potential of AI to enhance diagnostic accuracy, streamline workflows, and support clinical decision-making. This group appears to view AI as a valuable tool for improving patient safety and enhancing the quality of care.

- **No Impact on Risk:**

A smaller group of **40** respondents (**20%**) believes that the integration of AI will have no significant impact on the risk of medical errors. This viewpoint may reflect skepticism about the effectiveness of AI in addressing error rates or a belief that existing systems and processes are already adequate for ensuring patient safety.

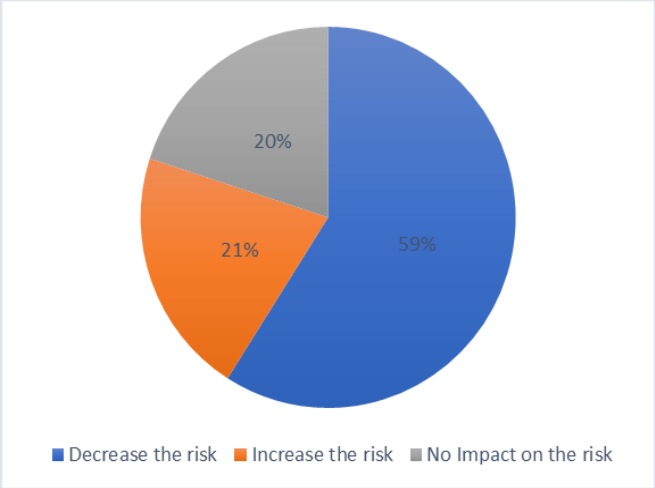

Figure (25): Perspectives on the Impact of AI Integration on the Risk of Medical Errors

6. Access to care in remote areas:

Based on the survey results regarding physicians' perceptions of whether artificial intelligence (AI) could enhance access to specialized healthcare in remote areas, the findings can be analyzed as follows:

- **Agreed:**

A significant majority of respondents, with **136** responses (**68%**), believe that AI could increase access to specialized healthcare in remote regions. This optimism may be attributed to the potential of AI technologies to bridge the gap in healthcare access by facilitating telemedicine, providing remote diagnostics, and enabling data-driven decision-making.

- **Disagreed:**

Conversely, **46** respondents (**23%**) express skepticism, indicating that they do not believe AI will enhance access to specialized care in remote areas. This perspective may come from concerns about the reliability of technology, infrastructural limitations in remote regions, or the need for human interaction in healthcare that AI cannot fully replicate. Physicians in this category might be worried that technological solutions alone cannot address the systemic issues related to healthcare access, such as lack of facilities or trained personnel.

- **No Opinion:**

A smaller group of **18** respondents (**9%**) reported having no opinion on the matter. This could reflect a lack of familiarity with AI applications in healthcare or uncertainty regarding the effectiveness of technology in addressing access issues. This group may benefit from further information and education about the capabilities of AI in improving healthcare delivery.

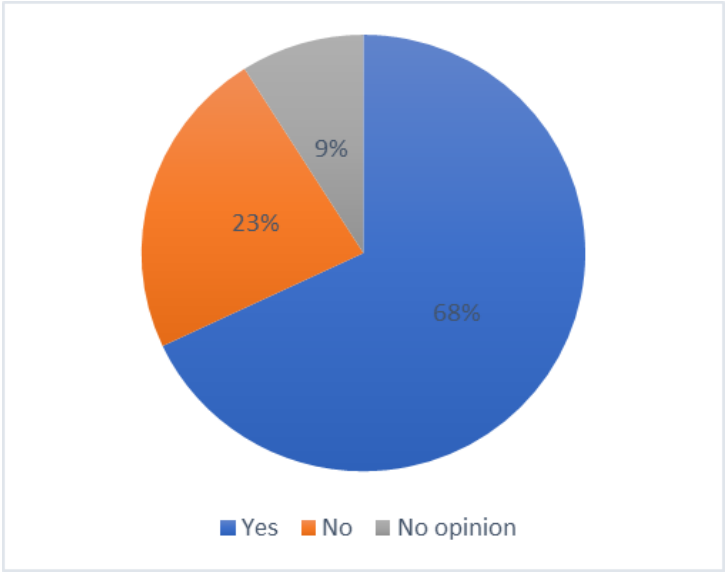

Figure (26): Views on AI's Potential to Improve Access to Specialized Healthcare in Remote Areas

Table (3): Key Considerations for AI in Medical Practice.

Characteristics		Total Headcount N (200)	Percentage
Confidence in AI			
	Not at All Confident	22	11%
	Slightly Confident	74	37%
	Moderately Confident	85	42%
	Very Confident	19	10%
Concerns regarding Patient Reaction			
	Negative Reaction	82	41%
	Positive Reaction	37	19%
	Neutral Reaction	51	25%
	No Opinion	30	15%
Physician-Patient Relationship			
	Positive Influence	79	40%
	Negative Influence	90	45%
	No Influence	31	15%
Data Confidentiality			
	Concerns about Data Confidentiality	131	65%
	No Concerns	36	18%
	No Opinion	33	17%
Patient Safety Incidents			
	Increased Risk	42	21%
	Decreased Risk	118	59%
	No impact on Risk	40	20%
Access to care in remote Areas			
	Agreed	136	68%
	Disagreed	46	23%
	No Opinion	18	9%

IV. Top Applications and Implementation Challenges:

1. Best Applications of AI in medical practice:

Based on the survey results regarding the best applications of artificial intelligence (AI) in medical practice, the findings can be analyzed as follows:

- **Medical Imaging Analysis:**

The most favored application, with **152** selections, highlights the significant role AI can play in enhancing the accuracy and efficiency of medical imaging. Physicians likely recognize AI's potential to assist radiologists in detecting anomalies, improving diagnostic precision, and reducing the workload associated with image interpretation.

- **Electronic Health Record Management:**

With **128** selections, this application underscores the importance of AI in streamlining administrative tasks. AI can enhance the management of electronic health records (EHRs) by automating data entry, ensuring data accuracy, and facilitating seamless information sharing among healthcare providers. This efficiency can lead to better patient care coordination.

- **Remote Patient Monitoring:**

Receiving **112** selections, this application reflects the growing importance of continuous patient engagement and monitoring. AI technologies can enable healthcare providers to track patients' health metrics in real time, allowing for timely interventions and improved outcomes, especially for chronic conditions.

- **Early Disease Screening:**

With **104** selections, this application indicates a strong belief in AI's capability to aid in the early detection of diseases. Early intervention is crucial for effective treatment, and AI can assist in identifying at-risk patients through data analysis and predictive modeling.

- **Disease Diagnosis:**

With **73** selections, this area illustrates the potential for AI to enhance diagnostic accuracy. By analyzing patient data and symptoms, AI systems can assist physicians in identifying conditions that may be overlooked, ultimately leading to more accurate and timely diagnoses.

- **Personalized Therapeutic Strategies:**

This application garnered **72** selections, reflecting interest in AI's ability to tailor treatment plans to individual patient needs. Personalized medicine can optimize therapeutic outcomes by considering genetic, environmental, and lifestyle factors.

- **Surgical Assistance:**

Although it received the least support with **50** selections, this application indicates recognition of AI's potential role in the operating room. AI can assist in various surgical tasks, improving precision and potentially enhancing patient safety.

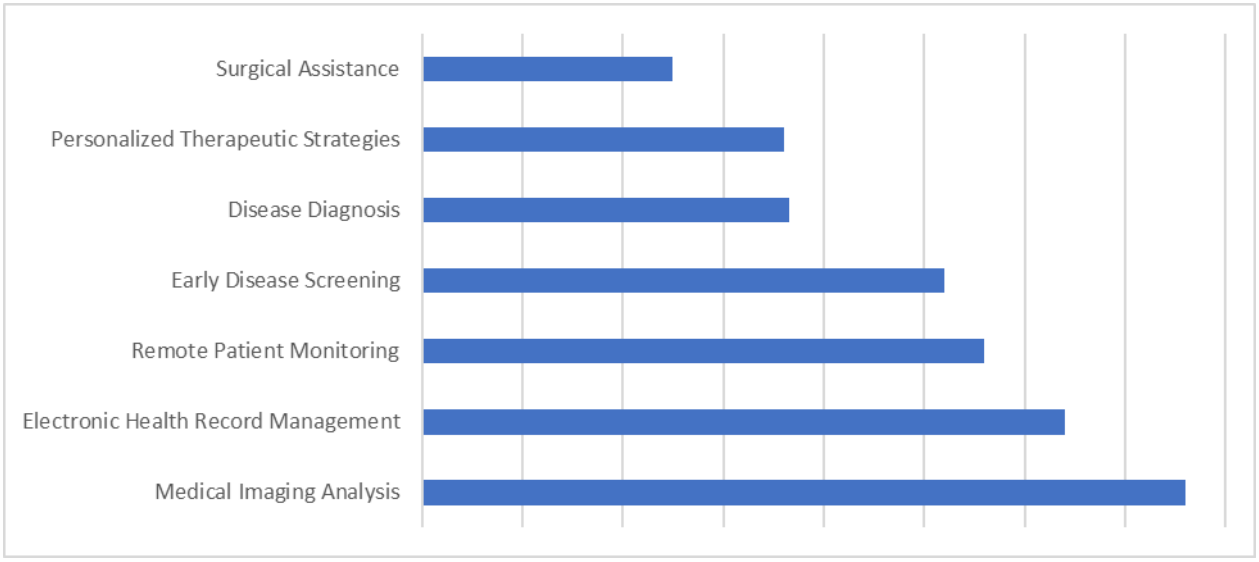

Figure (27): Preferred Applications of Artificial Intelligence in Medical Practice Among Physicians

2. Main challenges of AI implementation in medical practice:

Based on the survey results regarding the primary challenges or obstacles to the adoption of artificial intelligence (AI) in medicine, the findings can be analyzed as follows:

- **Loss of Human Aspect and Empathy in Interactions:**

The most significant concern, with **145** selections, indicates that many physicians worry about the potential loss of human connection in patient care due to AI integration. This perspective highlights the importance of empathy in healthcare and suggests that there may be fears that reliance on technology could deteriorate patient interactions.

- **Confidentiality and Security of Medical Data:**

With 113 selections, concerns about data privacy and security are prominent. Physicians are likely aware of the risks associated with data breaches and the importance of protecting sensitive patient information, which could hinder their willingness to adopt AI solutions.

- **Lack of Training and Knowledge Among Physicians on AI:**

This challenge received 108 selections, indicating that many physicians feel unprepared to integrate AI into their practice due to insufficient training. A lack of understanding about AI technologies could lead to hesitance in adoption and effective utilization.

- **High Costs of Implementing AI Technologies:**

Garnering 102 selections, the high cost associated with AI implementation is a significant barrier. Physicians may be concerned about the financial implications for healthcare facilities, especially in resource-limited settings where budget constraints are prevalent.

- **Lack of Trust in the Accuracy of AI Algorithms:**

With 93 selections, this challenge reflects skepticism regarding the reliability and accuracy of AI tools. Physicians may worry that incorrect AI recommendations could lead to misdiagnoses or inappropriate treatments, impacting patient safety.

- **Ethical Concerns Related to AI Use in Medicine:**

With by 69 selections, ethical considerations surrounding AI applications highlight worries about the implications of algorithmic decisions on patient care and outcomes. This concern underscores the need for clear ethical guidelines and frameworks as AI becomes more integrated into healthcare.

- **Potential Impact on Employment in the Healthcare Sector:**

This concern received 65 selections, indicating that some physicians fear that AI could lead to job displacement or changes in the role of healthcare professionals. This apprehension reflects broader societal concerns about automation and its implications for the workforce.

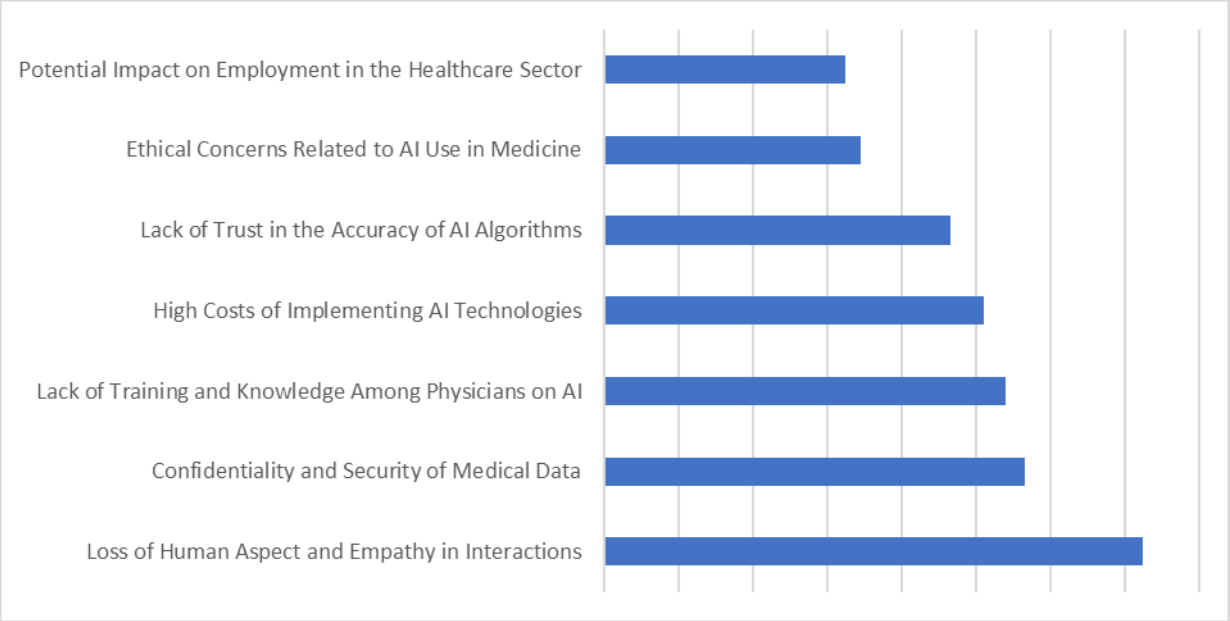

Figure (28): Main Challenges and Obstacles to AI Adoption in Medicine According to Physicians

Table (4): Top Applications and Implementation Challenges.

Characteristics		Response Frequency	%
Best Applications of AI in Medical Practice			
	Disease Diagnosis	73	36
	Early Disease Screening	104	52
	Medical Imaging Analysis	152	76
	Surgical Assistance	50	25
	Personalized Therapeutic Strategies	72	36
	Remote Patient Monitoring	112	56
	Electronic Health Record Management	128	64
Main Challenges of Implementing AI			
	Lack of Trust in the Accuracy of AI Algorithms	93	54
	Confidentiality and Security of Medical Data	113	56
	Loss of Human Aspect and Empathy in Interaction	145	72
	Lack of Training and Knowledge Among Physicians on AI	108	54
	High Costs of Implementing AI Technologies	102	51
	Potential Impact on Employment in the Healthcare Sector	65	32,5
	Ethical Concerns Related to AI Use in Medicine	69	34

- **Note on Data Interpretation:**

In the following summary table, the response frequencies and percentages represent the selections made by participants who were allowed to choose multiple options from a list of seven possible responses. As a result, the total number of selections may exceed the number of respondents, which is 200. Consequently, the sum of the percentages may exceed 100%.

V. Impact of AI on the professional lives of physicians:

1. Concerns About AI Potentially Replacing Medical Tasks:

Based on the survey results regarding physicians' concerns about artificial intelligence (AI) potentially replacing medical professionals in certain tasks or functions, the findings can be analyzed as follows:

- **Concerns About AI Replacing Multiple Medical Tasks**:

A total of **58** respondents (**29%**) expresses significant concern that AI could replace various medical tasks. This viewpoint may reflect fears about the growing capabilities of AI technologies and a belief that they could take over complex responsibilities traditionally held by healthcare professionals.

- **Concerns for Repetitive and Administrative Tasks:**

With **47** selections (**24%**), this group acknowledges that while AI may be capable of performing certain functions, it is limited to repetitive and administrative tasks. Physicians in this category might recognize the value of AI in streamlining workflows but still emphasize the necessity of human oversight in clinical decision-making.

- **Minimal Replacement of Medical Tasks**:

A total of **41** respondents (**21%**) believe that AI will only replace a limited number of medical tasks. This perspective suggests a more cautious view of AI's role, highlighting the unique skills and judgment that physicians bring to patient care, which cannot be easily replicated by technology.

- **AI Will Not Substitute Critical Medical Roles:**

The largest group, with **52** responses (**26%**), expresses confidence that AI will not replace physicians with their essential functions. This belief reflects an understanding of the importance of human empathy, intuition, and ethical considerations in healthcare, which AI cannot fully replicate.

Note: Two participants did not provide a response to this question.

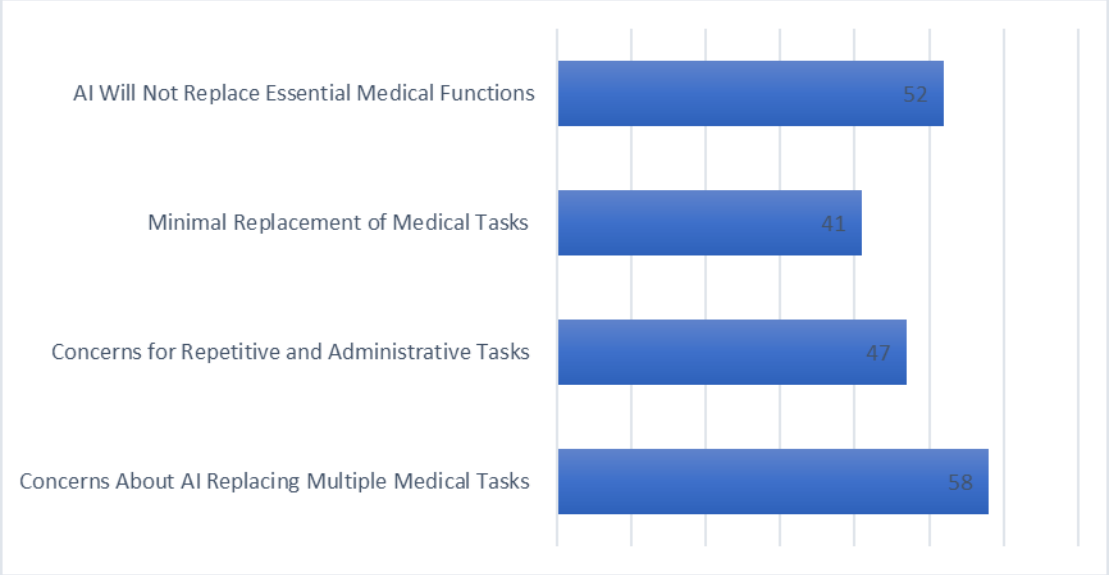

Figure (29): Concerns About AI Potentially Replacing Medical Tasks

2. Impact of AI on Physicians' Workload:

A significant majority of respondents (**136**), **68%**, believe that the integration of AI will help reduce the workload of physicians. This suggests a strong positive outlook toward AI as a tool that could alleviate some of the administrative or routine tasks currently burdening physicians, allowing them to focus more on patient care and clinical decision-making.

However, **23%** of respondents (**46**) are skeptical about AI's potential to reduce their workload. This group might have concerns about technology's effectiveness, potential disruption to existing workflows, or the possibility of additional complexities or responsibilities related to AI implementation.

Finally, **9%** of respondents (**18**) expressed no clear opinion, which could reflect a lack of sufficient knowledge about AI or uncertainty regarding its impact on their workload.

Overall, the results show a strong majority in favor of AI's potential to reduce physician workload, with a significant minority expressing doubt or uncertainty. This indicates that while AI is generally seen as beneficial, there are still some reservations and a need for further education or demonstration of its practical benefits.

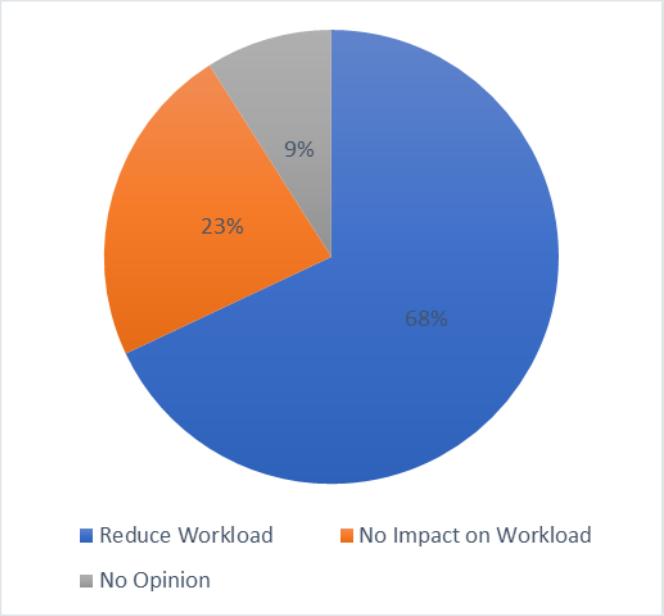

Figure (30): Perceptions of AI's Impact on Workload

3. Impact of AI on Professional Responsibility in Medical Practice:

Based on the survey results regarding physicians' views on how artificial intelligence (AI) will affect their professional responsibility in medical practice, the findings can be analyzed as follows:

- **Shared Responsibility Between Physicians and AI Developers:**

A significant majority, with **98** responses (**50%**), believe that AI will necessitate a shared responsibility between physicians and AI developers. This perspective highlights the recognition that both parties have roles in ensuring the safe and effective use of AI in healthcare, suggesting a collaborative approach to accountability.

- **Increased Responsibility for AI-Related:**

A total of **56** respondents (**28%**) feel that the integration of AI will increase physicians' responsibility in cases of errors related to AI. This concern reflects apprehension about the implications of relying on technology for critical decisions and the potential for physicians to be held accountable for outcomes influenced by AI systems.

- **Reduced Responsibility Through Delegation to AI:**

Only **17** respondents (**9%**) believe that AI will reduce their responsibility by delegating certain tasks. This small proportion may indicate a limited perception of the role AI can play in clinical decision-making, emphasizing that physicians still bear ultimate accountability for patient care.

- **Minimal Impact on Professional Responsibility:**

Lastly, **27** respondents (**13%**) feel that AI will not have a significant effect on professional responsibility. This viewpoint suggests skepticism about AI's influence on the dynamics of accountability in medical practice, indicating a belief that the fundamental responsibilities of physicians will remain unchanged.

Note: Two participants did not provide a response to this question.

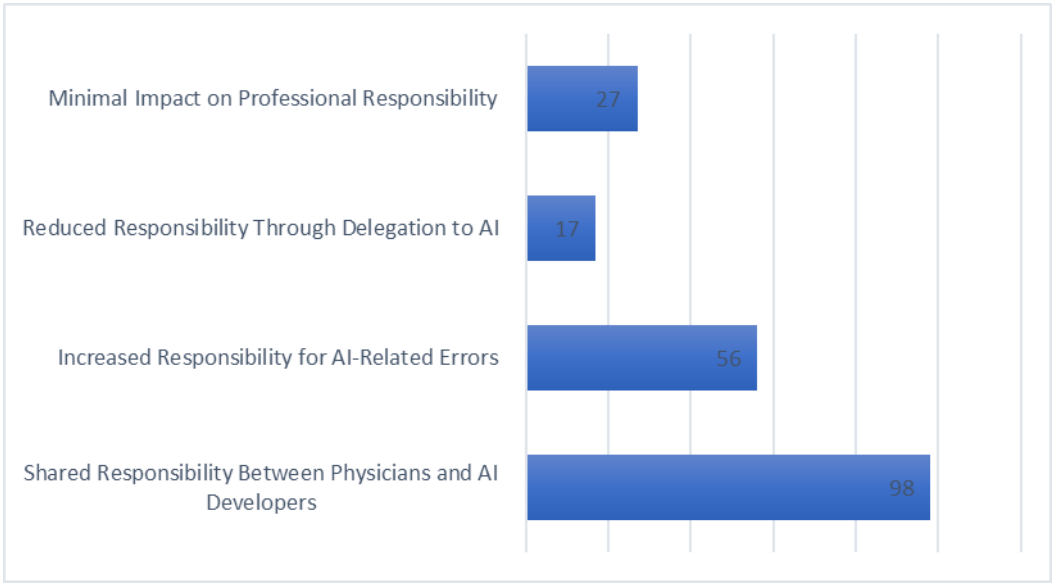

Figure (31): Perspectives on the Impact of AI on Professional Responsibility in Medical Practice

4. Impact of AI Adoption on Physicians' Professional Satisfaction:

Based on the survey results regarding physicians' perceptions of how the increasing adoption of artificial intelligence (AI) in medical practice could affect their professional satisfaction, the findings can be analyzed as follows:

- **Improvement in Satisfaction**:

A substantial majority, with **102** responses (**50%**), believe that the integration of AI would enhance their professional satisfaction. This optimism may stem from the potential for AI to streamline workflows, reduce administrative burdens, and support clinical decision-making, allowing physicians to focus more on patient care and less on repetitive tasks.

- **Decrease in Satisfaction**:

A smaller group of **39** respondents (**20%**) express concerns that AI could diminish their professional satisfaction. This perspective may reflect fears about losing autonomy, concerns over job security, or apprehensions about the quality of care being compromised due to reliance on technology.

- **No Impact on Satisfaction:**

Lastly, **59** respondents (**30%**) feel that the adoption of AI will have no significant impact on their professional satisfaction. This viewpoint may indicate a belief that, regardless of technological advancements, the core aspects of their roles as healthcare providers will remain unchanged.

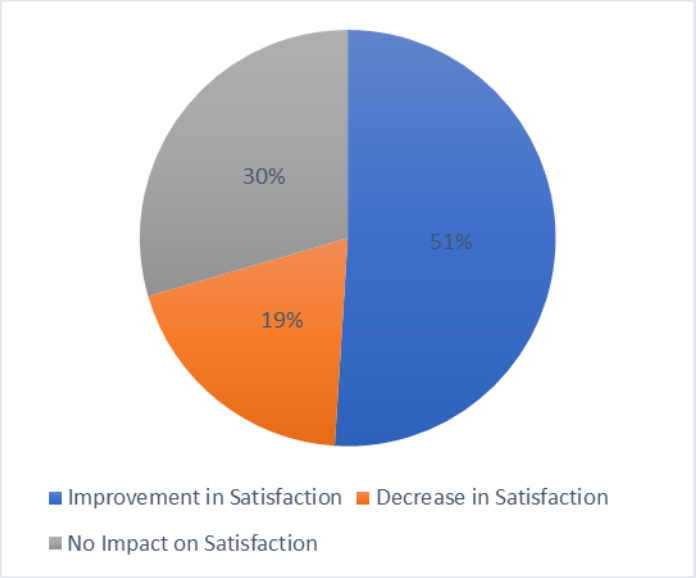

Figure (32): Impact of AI Adoption on Physicians' Professional Satisfaction

VI. Perspectives on AI Integration and Education in Medicine:

1. Opinions on the Increased Integration of AI in Medical Practice:

Based on the survey results regarding physicians' support for the increased integration of artificial intelligence (AI) in medical practice, the findings can be analyzed as follows:

- **Support for Increased Integration**:

A significant majority of respondents, with **112** responses (**56%**), express their support for the increased integration of AI in medical practice. This positive outlook suggests that many physicians recognize the potential benefits of AI, such as enhanced diagnostic capabilities, improved patient care, and increased efficiency in clinical workflows.

- **Opposition to Integration**:

In contrast, **52** respondents (**26%**) indicate that they are opposed to the increased integration of AI. This group may have concerns about the implications of relying on technology, such as potential threats to the physician-patient relationship, issues related to data privacy, or the risk of depersonalizing care.

- **No Opinion**:

A smaller group of **36** respondents (**18%**) reported having no opinion on the matter. This may reflect uncertainty about the benefits and challenges associated with AI in healthcare or a lack of familiarity with AI technologies.

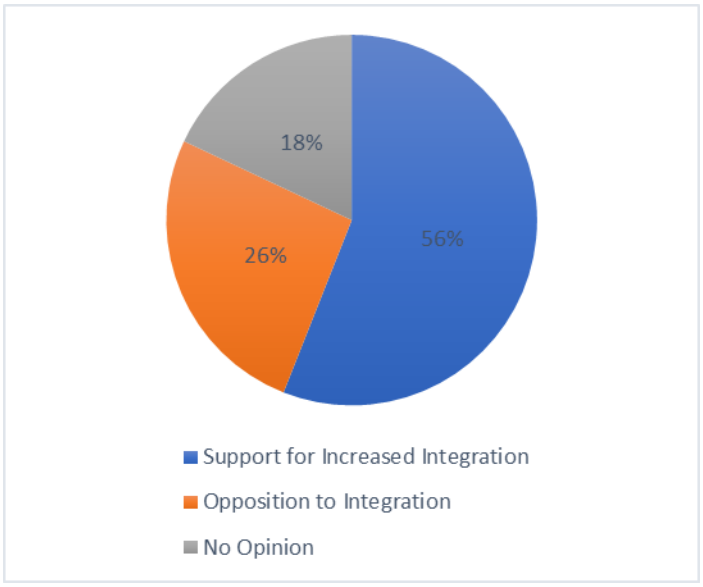

Figure (33): Support for Increased Integration of AI in Medical Practice

2. Intentions to Pursue Further Education on AI in Medicine:

Based on the survey results regarding physicians' intentions to deepen their knowledge of artificial intelligence (AI) and its applications in medicine, the findings can be analyzed as follows:

- **Strong Interest in Further Learning**:

An overwhelming majority, with **183** responses (**91%**), express a strong intention to enhance their understanding of AI and its applications in medicine. This enthusiasm indicates a recognition of the importance of AI in the future of healthcare and a desire to stay informed about technological advancements that could impact their practice.

- **Lack of Interest in Further Learning**:

Only **17** respondents (**9%**) indicate that they are unlikely to pursue further education on AI. This small percentage may reflect a sense of contentment with their current knowledge or a belief that AI may not significantly impact their practice in the near term.

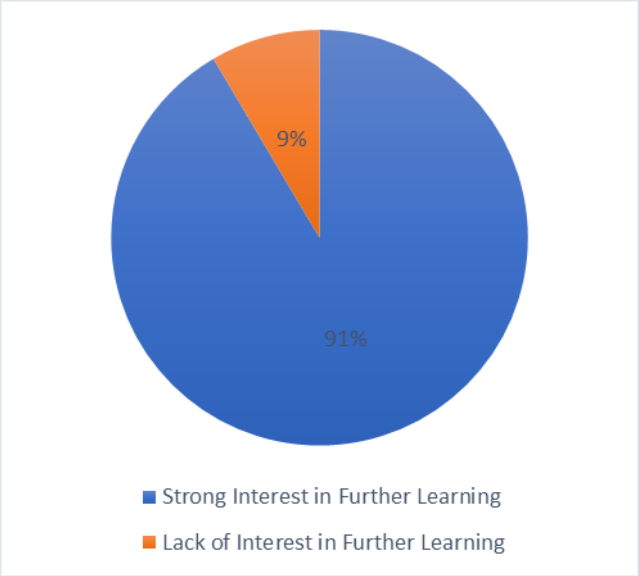

Figure (34): Intentions to Pursue Further Education on AI in Medicine

Table (5): Impact of AI on the professional lives of physicians.

Characteristics		Total Headcount N	Percentage %
Concerns About AI Replacing Medical Roles		N (198)	
	Multiple Medical Tasks	58	29%
	Repetitive and Administrative Tasks	47	24%
	Minimal Replacement of Medical Tasks	41	21%
	AI Will Not Substitute Critical Medical Roles	52	26%
Impact on Physician Workload		N (200)	
	Reduce Workload	136	68%
	No Impact on Workload	46	23%
	No opinion	18	9%
Impact on Professional Responsibility		N (198)	
	Shared Responsibility between Physicians and AI Developers	98	50%
	Increased Responsibility for AI-Related	56	28%
	Reduced Responsibility Through Delegation to AI	17	9%
	No Impact on Professional Responsibility	27	13%
Impact on Professional Satisfaction		N (200)	
	Improvement in Satisfaction	102	50%
	Decrease in Satisfaction	39	20%
	No impact on Satisfaction	59	30%

Table (6): Perspectives on AI Integration and Education in Medicine.

Characteristics		Total Headcount N	Percentage %
Opinions on Increased Integration of AI in Medical Practice			
	Support for Increased Integration	112	56
	Opposition to Integration	52	26
	No opinion	36	18
Intentions to Enhance AI Knowledge in Medical Practice			
	Strong Interest in Further Learning	183	91
	Lack of Interest in Further Learning	17	9

B. Moroccan Patients Interviews:

I. Population Characteristics:

The research included a cohort of ten individuals, comprising ten Moroccan patients who were equally divided by gender, consisting of five males and five females. The age range of the participants was between 25 and 65 years. This demographic composition offers a diverse viewpoint within the sample. Additional information concerning the participants is presented in Table 1.

Table (7): Characteristics of the Study Population

Gender	Age	Profession	Level of Computer Literacy	Interview Duration
Male	25 years	Business school student	Intermediate	20 min
Female	27 years	Computer engineer	Advanced	17 min
Male	32 years	Dentist	Basic	15 min
Female	30 years	Primary school teacher	Basic	22 min
Male	45 years	Entrepreneur	Intermediate	15 min
Male	28 years	Sales representative	Intermediate	17 min
Female	26 years	Nurse	Basic	15 min
Female	36 years	Pharmacist	Advanced	25 min
Male	65 years	Retiree	Intermediate	30 min
Female	52 years	Housewife	Basic	15 min

II. Exploring Moroccan Patients' Knowledge Toward AI:

1. Awareness of AI amongst Moroccan Patients:

Participants typically possess a basic awareness of artificial intelligence; however, their comprehension is frequently superficial. Many individuals exhibit curiosity regarding the subject, yet they often harbor uncertainties about the specifics and consequences of AI technology. This situation underscores the necessity for enhanced informational resources and educational initiatives to foster a deeper understanding and greater involvement with AI among this population.

- **P4:** "I've seen AI mentioned in the news and on social media, but I'm not sure what it really means."
- **P7:** "Many people in my circle talk about AI, but I think most of us have a basic understanding at best."
- **P1:** "AI seems to be everywhere these days, but I still find it hard to grasp how it works."
- **P8:** "I know AI is about machines and intelligence, but I'm curious about how it will affect our future."
- **P10**: "Personally, I really don't know what this is about."
- **P3:** "My colleagues often send me updates about AI machines, especially in our field. I know a little about algorithms and neural networks, but I don't have a clear and precise definition."
- **P2:** "AI is the new era of technology"

2. Generational Gap in Technology Adoption:

Certain participants indicate that computers are perceived as a tool that varies across generations, suggesting that their usage is more prevalent among specific age groups. They assert that older generations tend to exhibit resistance to advancements in technology, whereas younger generations demonstrate a greater familiarity with the functionalities of artificial intelligence.

- **P2:** "I come from a generation where computers have been present since a young age, so I've had a computer since I was around 10 or 11 years old."
- **P9:** "As always, we are often resistant to change."
- **P10:** "Younger people might accept it more easily because they know the capabilities of this new technology."

Some participants argue that the advancement of artificial intelligence in the healthcare sector benefits younger populations while disadvantaging older individuals.

- **P2**: "Our generation holds on, but the generation before us, like our parents, it's dramatic."
  In the end, the level of acceptance of artificial intelligence would depend on the generation in question.
- **P7**: "In my opinion, it all depends on the generations… if I think of my grandmother or our parents who are over 60, maybe they wouldn't be in favor of such things, while younger people might accept it more easily."
- **P5**: "Patient acceptance of something provided by a machine rather than a human will be very difficult, but it will become more natural with the younger generations."

3. AI Features for Moroccan Patients:

Artificial intelligence presents considerable benefits in contemporary society. It possesses the ability to analyze extensive datasets at remarkable velocities, greatly exceeding human performance. Furthermore, AI is capable of executing multiple tasks simultaneously, a feat unattainable by humans. Consequently, a growing number of individuals and professionals are integrating AI into their workflows to streamline processes and improve overall productivity.

- **P6**: "AI can process vast amounts of data in a short period of time."
- **P2**: "The speed at which AI analyzes large data is unbelievable."
- **P3**: "AI can accomplish multiple tasks at the same time, which is impossible for a human."
- **P8**: "Many people are starting to use AI, especially in their work, as it really simplifies several tasks for them."

AI is a program that can autonomously solve problems through data analysis and processing. It also possesses the ability to adapt and learn.

- **P6**: "For me, it's a program made up of many lines of code that are written by humans so that the program can then find the answers on its own."
- **P2**: Artificial intelligence keeps getting better over time. It learns more and more the more you use it.

4. AI compared to Human Abilities:

Although human brains possess the capacity for learning, they are constrained by limitations in memory. In contrast, machines are capable of storing extensive quantities of data. When programmed for particular functions, machines exhibit continuous improvement without experiencing fatigue or distraction, which enhances their efficiency, especially when compared to humans, who may be susceptible to making mistakes.

- **P1**: We can learn information, but our brains do not have the capacity to memorize everything. However, a robot, for example, can store all the information it receives.
- **P2**: If we teach a machine to perform a task precisely and perfectly, it will continuously work on improving that task without getting tired or distracted, especially in tasks requiring high concentration over extended periods, making the machine more efficient.
- **P7**: But a machine almost never makes mistakes.

5. Application of AI in Daily Life:

According to the perspectives gathered from our interviewees, computers are employed on a daily basis in both occupational environments and recreational pursuits. There exists a considerable disparity in the understanding of various AI applications among individuals. Each participant appears to possess awareness of a diverse range of applications, including social media platforms, facial recognition technologies, online customer support systems, video gaming, mobile devices, and safety protocols in the workplace.

- **P2**: "When a phone unlocks using facial recognition, for example, it is a form of AI."
- **P1**: "I believe that even video games, especially those of the latest generation, are built using AI.
- **P5**: "In airports, for example, we now use just the retina scan; it's fascinating that there's no need for paper to identify ourselves anymore."
- **P9**: "Yes, I use an audiobook reader and newspapers every day; that's also AI, isn't it?"

III. Patients Perceptions of AI in Healthcare:

1. AI Potential in Medical Practice:

Following the introduction of artificial intelligence to the patients interviewed, along with a thorough elucidation of its functions and applications, we can initiate a dialogue concerning their perceptions of this technology within the realm of medical practice. By examining their opinions and emotions related to AI, we acquire significant insights into their perspectives on its incorporation into their healthcare journey.

1.1 Hope and Uncertainty: AI in Morocco's Healthcare:

Patients exhibit a measured sense of optimism regarding the incorporation of artificial intelligence within Morocco's healthcare system. They recognize the difficulties associated with the current infrastructure but underscore the prospective advantages of AI in improving medical efficiency and patient care. This sentiment reflects a readiness to adopt technological advancements, especially if such innovations can result in substantial enhancements to healthcare practices.

- **P2**: "With this infrastructure in Morocco, it will be difficult to introduce AI in the healthcare sector, but if we manage to do so, it will certainly be a huge step towards development."
- **P10**: "If it will help physicians be more effective in their work, why not?"
- **P4**: "I've read somewhere that there are machines that assist surgeons during operations. that's good news "
- **P3**: "As long as it will improve patient care, I don't see why we shouldn't implement it in the near future."
- **P7**: "I have a friend who told me that there are even chatbots that function like Psychologists, it's a bit frightening expressing yourself to a robot, but it could be helpful."

1.2 AI Applications in Medical Practice:

The examples provided by most of the population relate to the use of AI in **diagnostic support, interpretation of medical imaging, treatment and prevention of chronic diseases.**

- **P8**: "For example, if we share our symptoms with an AI that has access to a comprehensive medical database, it could potentially diagnose the disease more quickly."
- **P2**: "A basic example is MRIs and scans to determine if there is cancer or not; AI can bring a lot by analyzing the images."
- **P3**: "If a physician misses something on medical images like MRI or CT scans due to inattention, AI could help by pointing it out."
- **P8**: "Maybe thanks to AI, we can discover new molecules to create new medications, especially for chronic diseases."

1.3 AI Role in Enhancing Administrative Efficiency:

Certain responses suggest that patients perceive artificial intelligence as a potential catalyst for substantial enhancements in hospital operations. This is especially evident in areas such as the management of patient records, appointment scheduling, and the overall administration of healthcare facilities. Patients regard AI as a mechanism that could streamline processes, alleviate the burden of administrative tasks, and ultimately elevate the standard of care provided.

- **P3**:"And also, in patient management and hospital database administration."
- **P5**: "If it could be used to manage patient records, appointment scheduling, and assist staff in hospital administration, it would be very helpful."
- **P9**: "Sometimes, hospitals lack administrative organization, and in this case, AI can really help."

1.4 Acceptance of AI: Focusing on Outcomes and Expertise:

In this segment, patients demonstrate a willingness to accept artificial intelligence in the healthcare sector, contingent upon its application as an auxiliary resource managed by qualified medical professionals. Although there may be initial apprehensions regarding the technology, patients emphasize the importance of effective results and high-quality care over the particular instruments employed. They anticipate that, with time, AI could be integrated into standard healthcare practices if it contributes to improved patient outcomes.

- **P1**: "It's not a problem for me if a physician uses AI, as long as it is just a professional assistance tool and he masters it and remains responsible for the technology they use."
- **P9**: "The most important thing is the result. If I receive good care, that's what matters to me. "
- **P2**: "At first, it might feel a bit strange because we're not used to it, but over time, it would become a normal thing."
- **P4**: "As long as the physician controls and masters the tools they use; it doesn't bother me at all."

2. Main Challenges and Concerns in AI Integration:

2.1 Challenges in Funding and Implementing New Technologies in Morocco:

Certain patients articulate apprehensions regarding the government's current capacity to allocate funds for the development of new technologies. There exists a prevailing sentiment that the nation is deficient in the financial resources necessary for such investments, suggesting that the implementation of these technologies in Morocco may be significantly delayed.

- **P4**: "I don't think the government can make this investment right now. It would take time, of course, but there's not much we can do about it."
- **P6**: " I'm not sure if our country currently has the financial capabilities to implement these new technologies. I think it will take some time before they are implemented here in Morocco. "
- **P7**: "It would certainly take years for our country to integrate these new technologies into the healthcare sector."

2.2 Concerns About the Security and Confidentiality of Digital Medical Records:

Many participants express apprehensions regarding the safety of digital medical records. They contend that physical records, when properly secured, offer greater safety compared to their digital counterparts, which may be susceptible to weaknesses in online security frameworks. Patients emphasize the necessity for stringent security protocols to safeguard their confidentiality and assert that any unauthorized access to their medical data would be intolerable. For these individuals, maintaining confidentiality is of paramount importance.

- **P10**: "It is true that medical records are more at risk when stored digitally than when kept in securely stored paper files with the secretary."
- **P2**: "Yes, it is a bit concerning because there will likely be vulnerabilities in the security system. It's essential to adopt robust security measures to protect patient confidentiality. "
- **P9**: "Of course, I do not accept that others, whom I do not know, have access to my medical records. It's true that if it were on online platforms with a standard security system, it would bother me a lot. "
- **P5**: "For me, confidentiality is essential."

2.3 Concerns Over AI Malfunctions and Vulnerabilities in Early Stages:

The integration of artificial intelligence in the healthcare sector raises significant concerns that warrant attention. Many participants have articulated these apprehensions. In particular, there are fears regarding the possibility of AI system failures, which may result in errors within medical practice.

- **P6**: "The concern is that mechanical systems can sometimes… well, there's a certain level of judgment that might be missing. I don't know how to explain it, but while a computer works incredibly fast, which is amazing, it can also crash. So, I wonder, if a robot were performing surgery, what might happen if something went wrong?"
- **P7**: "Moreover, AI still makes mistakes today, and at the slightest error, my health is at risk."

Some participants express concerns that AI would not be exempt from design flaws, and malfunctions could potentially lead to accidents.

- **P4**: "Objectively, nothing is truly perfect. Some things can be poorly designed."
- **P2**: "These are the limits, and even beyond them, there are real risks. If an error occurs in healthcare, it's a matter of someone's life being at stake."

Other concerns from the surveyed population focus on the digital aspect and the risks associated with it. The vulnerability of AI systems is seen as arising from their dependence on computer technology. Their functionality could be threatened by data hacking, and some even fear the possibility of AI being hacked to create new diseases.

- **P1**: "The entire computer system can be compromised. Everything relies on computers now, and there's a certain fragility to this system."
- **P7**: "Another issue is all the data. what happens when two or three hospitals were hacked nothing will work anymore."
- **P9**: "You could have crazy people everywhere, like someone using AI to create a new virus, like a 'Covid 2."

2.4 Skepticism Toward AI in Critical Medical Procedures:

In this section, participants express skepticism about trusting AI in critical medical areas like surgery. While they acknowledge the potential benefits of AI in healthcare, they emphasize a strong preference for human expertise, particularly when it involves high-stakes procedures. Many believe that it will take a considerable amount of time for Moroccan patients to fully trust AI in these situations.

- **P8**: "Maybe AI can help with everything medical, but it's true that if you ask me right now to choose between a surgical robot powered by AI or an experienced surgeon for an operation, I would definitely choose the surgeon."
- **P9**: "In surgery, I don't think Moroccan patients will trust a surgical robot in the future. It will really take a long time to adopt that mindset."
- **P6**: "AI could be useful for routine tasks in healthcare, but when it comes to something as important as surgery, I would always feel safer with a physician who has years of experience. Trust is built on human skills, not just technology."
- **P10**: "During an operation, it's my life that's at stake. I would never give a robot permission to handle that."

2.5 Ethical Concerns and the Right to Transparency in AI Usage:

In this section, patients express strong ethical concerns about the use of AI in healthcare, emphasizing their right to be informed if AI is involved in their care. They believe transparency is essential for maintaining trust and ensuring that patients can make informed decisions about their treatment.

Some patients worry that s may hide the use of AI, raising ethical issues around honesty and patient autonomy. To address these concerns, they suggest implementing laws that encourage full disclosure, ensuring that AI is used ethically, and patients' rights are respected.

- **P5**: "Yes, I believe I have the right to know if my physician is using AI in my care."
- **P2**: "Absolutely, it is important to inform patients that AI is being used. I think it would be wise on their part to do so. "
- **P10**: "I have the right to be informed."
- **P1**: "It is possible that some physicians may hide the use of AI in their work, but it is essential to implement a law that encourages them to disclose this information."
- **P8**: I think it is necessary to mention this to patients. Maybe some of them will refuse the use of AI, and it is their right to do so.

3. Key Factors in Building Trust and Optimizing AI integration:

3.1 The Importance of Physician Presence in the Patient-Centered Relationship:

In this part, patients emphasize the importance of the physician's presence in the physician-patient relationship. They believe that sharing concerns and feelings with a physician is vital for both psychological and physical well-being. While they acknowledge that machines can assist with administrative or support tasks, they consider that the human aspect of healthcare should be preserved. The presence and support of the physician help reduce stress and build trust, with the physician's role remaining essential and undeniable.

- **P7**: I think it is important for me to share my concerns and sometimes my feelings with my physician. It really helps to have someone listening. So, if we are only faced with a machine without the constant presence of the physician, it would, of course, diminish the quality of the physician-patient relationship."
- **P1**: Maybe when delivering certain diagnoses, like telling someone they have cancer or informing parents that their child has a serious condition... I believe that should always be done by a person."
- **P9**: There's nothing better than leaving a physician's office where they've listened to all your concerns. It makes you feel much calmer and less stressed. I think machines should handle administrative or support tasks, while keeping, above all, the human aspect in the relationship between the patient and their physician."
- **P3**: The physician will, of course, maintain their status, and their presence remains undeniable."
- **P2**: But then again, I also think that sometimes when physicians are overwhelmed, they tend to treat the patient…it's not the right term, but treat the patient like a number, rushing through things because there's no time. And why not look at it from a positive perspective? If AI allows the physician to have more time to focus on more important things, like the patient's mental well-being, it could even improve the physician - patient relationship.

3.2 The importance of constant monitoring and updating of new technologies:

Some participants emphasized the importance of constant monitoring and collaboration between AI experts, technicians, and physicians. They highlighted the need for these professionals to work together to ensure the machines function properly and receive necessary updates.

- **P2**: The monitoring of such machines is essential; it is imperative to have a technician and an expert available.
- **P5**: AI experts, computer engineers, and physicians must work together to ensure the proper functioning of machines on a daily basis and perform the necessary updates.

3.3 The Importance of Training Physicians in AI Technology:

Some participants also emphasized the critical importance of properly training healthcare professionals, particularly young physicians, on the use of new technologies like AI. They believe that adequate training is essential to ensure that these tools are used correctly and safely. Without proper education and guidance, there is a risk of misuse, which could compromise patient care. This highlights the need for ongoing professional development to integrate AI into medical practice effectively while maintaining high standards of care.

- **P3**: "But above all, healthcare professionals, especially young physicians, must be properly trained on these new technologies to ensure correct and safe usage."
- **P9**: "We must not forget that it's essential to properly train these physicians."
- **P6**: "There needs to be constant updating between physicians and AI experts to keep them informed of new developments."

4. Main Hopes of Moroccan Patients for AI in Healthcare:

4.1 Advancements in Surgery and Diagnostic Precision:

During the interviews, the participants highlighted several potential improvements to the healthcare system through AI, hoping to optimize its efficiency. Among these, they mentioned advancements in surgery, using AI and robotics to enhance the technical aspects of care.

- **P3**: "To make the system more efficient."
- **P5**: "Because I remember surgeries where we were hospitalized for 15 days, and now they are done with lasers or with a system that allows for surgery without having to make an incision. So, I think that in the future, it would be great to further improve all of this."

Others shared the possibility of using AI to enhance medical capabilities, such as improving diagnostic performance.

- **P8**: "We can increase the accuracy of surgeons in removing tumors that were previously inaccessible or detecting lumps that wouldn't be visible to the naked eye, like with scanner analysis."
- **P6**: "It could potentially improve it. As if there were two brains instead of one, it might help the physician make a decision, or if they have doubts, it could be complementary and reinforce the diagnosis, leading to better care."

According to some participants, AI could significantly enhance medicine by saving time, leading to faster diagnoses.

- **P4**: "It will be a major time saver. Physicians will be able to work much more quickly." **P1**: "Take the COVID vaccine as an example. I don't know how fast it was developed, but thanks to AI and all the calculations and data analysis, a vaccine was produced, something we could never have done during the last epidemic 100 years ago." **P8**: "We'll be able to detect conditions earlier. It will take less time than it does today, even though things are already fairly quick."

4.2 Advancements in Preventive Care and Accessibility:

Additionally, some participants explained that this technology could enhance predictive and preventive medicine. They believe it could also reduce the long-term costs of preventive treatments.

- **P3**: It could also help in genetics, for example, if we are predisposed to certain diseases. AI could warn us and help prevent factors that could trigger these conditions.
- **P2**: It could really extend life expectancy through prevention, for example.

Some participants suggested that AI could help streamline the development of telemedicine, potentially leading to the establishment of an autonomous medical consultation program. AI could also enhance the medication delivery system, improving efficiency and accessibility.

- **P1**: There will certainly be more telemedicine consultations thanks to these new technologies.
- **P5**: "AI could make it so much easier to have medical consultations online, so people wouldn't always have to go to the physician's office. It would make healthcare more accessible."
- **P8**: "With AI, getting medications to people could be quicker and smoother. It could help ensure patients get what they need, without having to wait so long."
- **P6**: "Some medications and tests are not available in Morocco, and they have to be sent abroad for processing. AI could help reduce the waiting time for results, making the whole process faster and more efficient.

DISCUSSION

I. AI technology in Medical Practice:

1. Medical Interview:

Artificial intelligence (AI) is significantly reshaping modern medicine, particularly in the context of **medical interviews**. This vital phase, during which the clinician collects critical information from the patient, is essential for formulating an initial diagnosis and planning subsequent treatment strategies. The integration of AI into this process accelerates the interview, enhances its accuracy, and tailors it to individual patient needs[41].

Sophisticated **medical chatbots**, **automated triage systems**, and cutting-edge **natural language processing tools** are capable of interpreting patient responses, modifying inquiries in real-time, and providing diagnostic recommendations[42].

Consequently, AI not only enhances the quality of the interview but also improves the overall efficiency of medical care, while reducing the cognitive load on physicians.

1.1 Medical Chatbots and Virtual Assistants:

Medical chatbots and virtual assistants that utilize artificial intelligence (AI) are transforming the process of conducting **medical interviews**. These AI systems engage in conversation with patients, employing algorithms to pose a series of focused questions. The aim is to **collect vital information** regarding the patient's **symptoms**, **medical history**, and **lifestyle** in a clear and conversational way[9].

These virtual assistants can quickly analyze the responses, recognize patterns, evaluate the seriousness of symptoms, and even propose initial diagnoses based on comprehensive medical databases and knowledge systems.

These chatbots aim to assist in the initial phases of patient consultations by providing an early assessment that empowers patients to make informed choices. Based on the details shared, the system might **recommend self-care options**, **propose a potential diagnosis**, or **suggest that the patient consult a healthcare professional**. Besides enhancing efficiency and minimizing unnecessary in-person appointments, they also help address the increasing demand for healthcare services[43].

- **Patient-Engaged Medical Chatbots**

Patient-engaged medical chatbots are AI-driven tools that facilitate direct communication with individuals looking for medical guidance. These systems allow patients to share their symptoms and medical history, enabling the chatbot to evaluate this information instantly to determine the patient's health condition.

Some examples of such chatbots in use:

- **Babylon *Health®*:**

This platform offers virtual consultations via an AI-powered chatbot that interacts with patients by asking about their symptoms. Depending on the patient's answers, the chatbot provides an initial diagnosis, recommends self-care options, or suggests that they consult a healthcare professional for further evaluation. Babylon Health® helps streamline decision-making, minimizing the necessity for immediate in-person appointments[44].

- ***Buoy Health®:***

Buoy Health® uses AI to help patients recognize their symptoms and offers possible diagnoses based on the information provided. The chatbot then guides the patient on whether they need to seek immediate medical attention, book an appointment, or handle the condition with self-care[45].

1.2 Symptom analysis and intelligent triage:

- **AI-Enhanced Medical Interviewing for Physicians:**

This type of chatbots assists physicians by collecting and analyzing patient data using **Intelligent Triage systems**, thereby reducing cognitive load and improving the efficiency of the diagnostic process. These systems can conduct preliminary assessments, allowing physicians to focus more on diagnosis and patient care.

- **Infermedica®:**

An AI-powered triage system designed to assist physicians by guiding them through patient interviews. The system asks a series of diagnostic questions, analyzes the responses, and generates a list of possible conditions, which are then presented to the physician to support further examination and decision-making[46].

- **Ada Health®**:

Ada® supports physicians by collecting patient responses and processing the data to provide insights and potential diagnostic suggestions. This tool helps clinicians navigate complex medical histories and symptom presentations, ultimately saving time in the diagnostic workflow[47].

- **Nuance Dragon Medical®**:

A speech recognition and AI-powered software that uses **Natural Language Processing (NLP)** helping physicians streamline the documentation process and enhance patient interaction[48].

With its **ability to transcribe and interpret medical language in real-time**, it significantly reduces the time needed for manual charting. It integrates seamlessly into clinical workflows, allowing physicians to dictate notes and process medical data.

The **NLP** technology integrated into this type of chatbots allows it to understand complex medical terminology, improving the accuracy of dictations and enabling seamless interaction between the physician and the system[48].

1.3 Risk assessment and prediction:

Certain AI solutions utilize data gathered during medical interviews to evaluate the risk of specific health conditions. By comparing this information with extensive pathology databases, these AI systems can forecast the chances of developing certain diseases or recommend suitable diagnostic tests.

This approach not only helps in identifying potential health risks at an early stage but also supports more informed decision-making regarding subsequent steps in patient care. These AI-driven tools examine patient responses during their medical interviews, combining this data with historical health records, lifestyle factors, and broader population health trends.

Furthermore, AI systems can identify **risk factors** such as **genetic predispositions**, **lifestyle choices**, and **environmental influences** that may increase the risk of developing certain conditions. The aim is to deliver a personalized risk assessment that can assist in early detection, disease prevention, or customized interventions for chronic conditions[49].

- **IBM Watson for health®** uses advanced **AI and machine learning models**, including **deep learning**, to **assess the risk of chronic diseases** by analyzing patient medical histories and clinical data. It combines this information with data from medical interviews to **predict the probability** of disease development such as diabetes, heart disease, or other chronic illnesses, allowing physicians to implement **preventive strategies** or suggest additional **diagnostic tests** based on a more precise risk assessment[50].

1.4 Mental health assessment:

AI-powered chatbots such as **Wysa®** and **Replika®** are becoming essential tools for **mental health assessment** and **support**. Utilizing **NLP and machine learning**, these chatbots engage users in **real-time conversations**, allowing them to express their feelings, reflect on their mental well-being, and monitor mood fluctuations[51].

By analyzing user interactions, these systems can **detect early signs of conditions** such as **anxiety, depression, PTSD**, or other psychological issues based on patterns in the user's responses and offer immediate emotional support, propose coping strategies by providing evidence-based **cognitive behavioral therapy** (CBT) techniques and, when appropriate, advise seeking professional assistance[51].

2. Physical examination:

The integration of Artificial Intelligence (AI) into the physical examination phase represents a transformative advancement in medical practice. The physical examination is conventionally divided into four primary components: Inspection, Palpation, Percussion, and Auscultation. These steps allow clinicians to systematically assess physical signs that can provide critical insights into underlying pathologies.

However, AI technologies are increasingly enhancing these conventional methods, equipping clinicians with advanced tools to analyze data more quickly and accurately, often in real time.

From AI-powered stethoscopes that can identify heart murmurs and unusual lung sounds to AI-driven skin evaluation tools that enhance early detection of skin cancer, AI is revolutionizing clinicians' diagnostic capabilities and efficiency.

In this section, we will explore the most important AI technologies currently being integrated into each phase of the physical examination across **key medical specialties**, focusing on their ability to support **diagnostic precision and early detection**. These innovations not only help physicians identify conditions more quickly but also ensure that patients receive more personalized and timely care.

- **Cardiology**
  - **Eko® AI-Powered Stethoscopes**

AI-enabled **stethoscopes**, such as those developed by **Eko®**, represent a significant advancement in the **auscultation** phase of the physical examination. These devices utilize AI algorithms to analyze **heart sounds in real-time**, allowing for the detection of **arrhythmias, and other abnormal heart murmurs**. Eko® has re-engineered the traditional stethoscope by incorporating **amplification and noise cancellation technologies** to eliminate distracting background noise, thereby enhancing the clarity of auscultation. By processing acoustic data and comparing it with extensive clinical databases, AI-powered stethoscopes provide clinicians with **immediate, evidence-based feedback**. This technology enhances diagnostic accuracy, facilitates the early detection of conditions such as **heart failure or valvular heart disease**, and offers the potential for more timely clinical intervention[52].

Figure (35):
Advanced Auscultation Technology: The Eko® CORE 500™ Digital Stethoscope with ECG Capabilities[53].

- **Pediatrics**
  - **StethoMe®**

AI-powered software designed to enhance **pulmonary auscultation in pediatric patients**. Trained on a **database of 6,000 auscultations**, the system was evaluated in a clinical setting by five pediatricians using auscultations from 50 consultations. The gold standard for comparison was the diagnosis of a pulmonologist, followed by assessments from two pediatricians and, if needed, an acoustician.

The AI showed a higher level of agreement with the pulmonologist, with its performance varying slightly depending on the type of anomalies to be detected (**the AI was particularly accurate in detecting crackles and rhonchi**). On average, the AI correctly classified 100 auscultations, making 160 errors, compared to 184 errors made by pediatricians. This AI solution is already commercially available and also accessible to parents of children with **asthma**[54].

Figure (36):
StethoMe® Advanced Pediatric Pulmonology Device and Dashboard Interface[54].

- **Pulmonology**
  - **Onescope®**

An AI-powered project developed to assist in the early diagnosis and management of pulmonary conditions, particularly in the context of **lung auscultation.**

It is an initiative supported by **the University Hospitals of Geneva since 2017** and is primarily focused on utilizing AI to interpret lung sounds to detect abnormalities such as wheezes, crackles, and other indicators of respiratory disorders like **asthma, pneumonia, and chronic obstructive pulmonary disease (COPD)**[55].

Onescope uses advanced machine learning algorithms to analyze recorded lung sounds and compare them against vast databases of normal and abnormal lung patterns.

Figure (37):
Onescope® Innovative AI Powered Lung Auscultation Device and Mobile App Interface[55].

- **Otorhinolaryngology/ pediatric:**
  - **Smartscope®**

The Smartscope® is an innovative, AI-powered endoscopy tool designed to enhance the diagnosis of acute otitis media (AOM) in pediatric patients. Developed by Dr. Schmoll, this device serves as an adapter for smartphones, enabling direct visualization of the tympanic membrane and facilitating easier diagnosis. **Coupled with the I-Nside® application**, which utilizes AI to provide diagnostic probabilities, the Smartscope® aims to improve diagnostic accuracy in challenging clinical situations such as AOM[56].

A study evaluated **the effectiveness of the Smartscope® and I-Nside in a pediatric emergency setting**. It compared inter-rater agreement on AOM diagnoses between junior physicians using this technology and senior physicians using traditional otoscopes. Conducted at **CHU Lenval in Nice** from June 2021 to August 2022, the study included 200 children, divided into two phases:

The first phase involved standard otoscopic diagnosis, while the second incorporated the Smartscope® with I-Nside for junior physicians.

Results showed a significant increase in diagnostic concordance, rising from 72% in phase one to 95% in phase two ($p<0.05$), with a Fleiss kappa coefficient improving from 0.4 to 0.9[56].

Figure (38): Presentation of the SmartScope® and other components of the device[57].

Figure (39): Visual of the i-Nside® application[57].

3. Paraclinical tests:

The integration of artificial intelligence (AI) in paraclinical tests is transforming the diagnostic landscape in medical practice.

Paraclinical tests, encompassing laboratory assays, imaging modalities, histopathological evaluations, and additional essential tests such as electrocardiography (ECG) and spirometry, are crucial for precise diagnosis and therapeutic planning. Artificial intelligence technologies, including machine learning algorithms and computer vision, significantly enhance the accuracy and efficiency of interpreting complex data sets.

For instance, AI can analyze medical images such as CT scans and MRIs detecting subtle patterns and abnormalities that may be overlooked by human radiologists. In laboratory settings, AI algorithms streamline workflows by automating result analyses and identifying trends in large datasets, enabling clinicians to make timely and informed decisions.

- **Cardiologs® Holter for ECG interpretation:**

Cardiologs® is a cutting-edge AI platform developed by **Philips®** that enhances the accuracy of electrocardiogram (ECG) interpretations. Leveraging deep learning algorithms, Cardiologs® can identify a broad spectrum of cardiac abnormalities, including arrhythmias, with a level of precision comparable to that of experienced cardiologists. This advanced technology streamlines the diagnostic process, enabling physicians to focus more on patient care[58].

Cardiologs® has been shown to improve the specificity in atrial fibrillation (Afib) detection from **82.8% to 96.9%**, while **maintaining comparable sensitivity**, and it **divides by ten the number of false positive Afib episodes compared to traditional ECG analysis solutions**. The algorithm detects more than **20 types of arrhythmias** and is built on over **20 million recordings**[59].

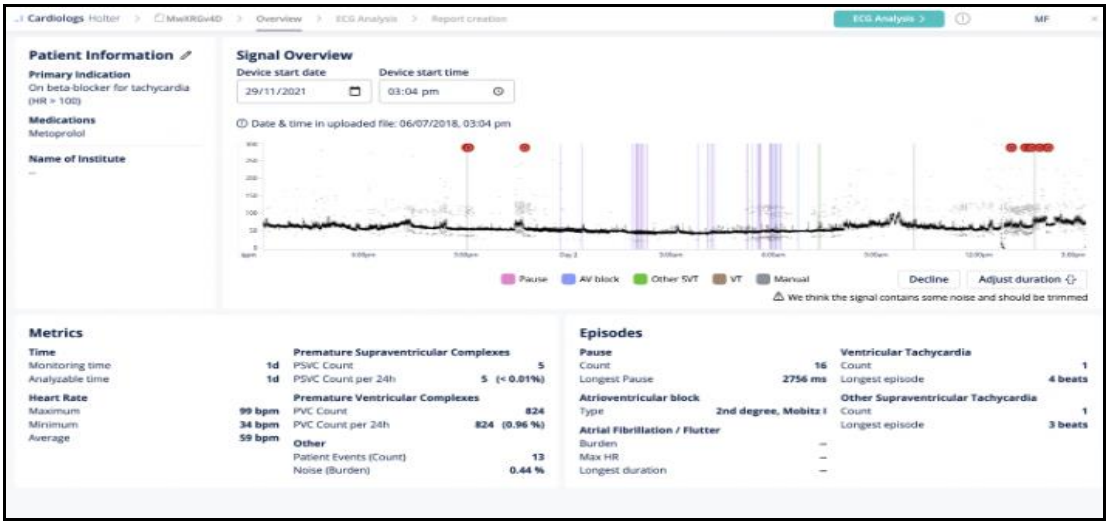

Figure (40): Cardiologs® Holter Platform dashboard (Screenshot from Website)[59].

- **Anumana® ECG-AI LEF**

The Anumana® ECG-AI LVEF (**Electrocardiogram AI for Left Ventricular Ejection Fraction**) is an advanced AI-based system designed to enhance the analysis of electrocardiograms (ECG) during physical exams. This system uses artificial intelligence to assess the left ventricular ejection fraction (LVEF), a key indicator of heart function, by interpreting standard ECG data. Anumana's AI algorithms can detect subtle changes in the heart's electrical activity that may go unnoticed by traditional methods, providing clinicians with more accurate insights into cardiac health. The ability to assess LVEF in real-time aids in the early identification of heart failure and other cardiovascular conditions[60].

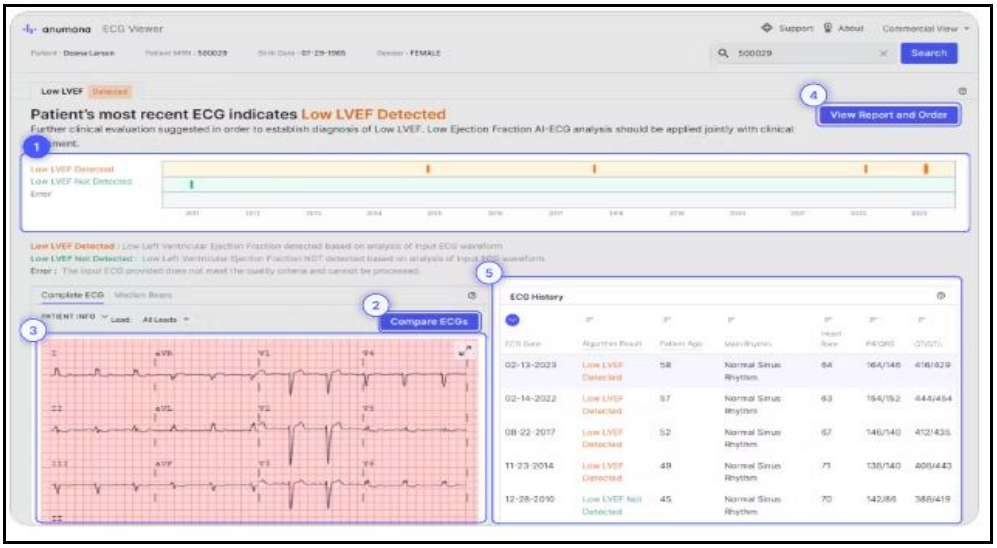

Figure (41): Anumana® Web Based Dashboard: ECG Viewer[60].

- **SentrySuite® Software for Spirometry:**

SentrySuite® is an advanced AIpowered software designed to **enhance spirometry and pulmonary function testing** in both clinical and research settings[61].

This platform leverages artificial intelligence to provide realtime, automated analysis of spir ometry data, including key metrics such as Forced Expiratory Volume (FEV1), Forced Vital Capacit y (FVC), and the FEV1/FVC ratio, which are critical for diagnosing and managing respiratory condi tions like COPD, asthma, and restrictive lung diseases[61].

This software also generates comprehensive reports with graphical representations of lung health, streamlining the diagnostic process and significantly improving workflow efficiency. Its cl oud integration further supports secure storage and long-term patient monitoring[61].

Figure (42): Sentry Suite® Master Screen spirometer[62].

- **AI Innovations with FlexView®, MONAI®, and Aidoc®:**

FlexView® from Radical Imaging is a **cloud-based medical imaging viewer** that enhances the visualization and analysis of medical images through AI technology. It integrates with **NVIDIA's MONAI® framework**, providing advanced image analysis capabilities[63].

FlexView® offers various modes of operation, including Basic Viewer, PET/CT, and Microscopy modes, along with advanced tools like multi-planar reconstruction and a 3D crosshair. Its dynamic plugin support enhances functionality, while its zero-footprint, web browser-based design ensures secure and efficient access to medical images without the need for software installation[63].

Recently receiving **FDA approval for diagnostic use**, FlexView represents a significant advancement in medical imaging, equipping physicians with effective tools for accurate and timely diagnostics[63].

Figure (43): FlexView® Platform dashboard Basic Viewer Mode (Screenshot from Website)[63].

- **NVIDIA's MONAI® Integration**

NVIDIA's MONAI® (Medical Open Network for AI) is an open-source framework that supports the development of AI models for medical imaging. It provides essential tools for data labeling, training, inference, and deployment, facilitating the creation of robust AI solutions across various modalities, including MRI and CT scans[64].

The integration of MONAI® with platforms like FlexView demonstrates the transformative potential of AI in medical imaging, enabling clinicians to achieve enhanced diagnostic accuracy and improved patient outcomes[64].

- **Aidoc®**

Aidoc® is an innovative AI-driven platform that significantly enhances medical imaging analysis. By leveraging advanced machine learning algorithms, this platform efficiently analyzes radiological images to identify critical conditions such as hemorrhages, pulmonary embolisms, and fractures[65].

- **AI Innovations in Ultrasound and CT Imaging:**

Examples of new ultrasound devices, such as the **LOGIQ E10®** by GE Healthcare, use advanced AI tools like Auto Lesion Segmentation and Auto Doppler Assistant to enhance diagnostic accuracy[66].

For CT scans: **The Aquilion Prime SP® CT scanner** by Canon Medical Systems employs AI to adjust radiation doses for each patient, ensuring high-quality images with minimal exposure.

This advanced scanner also features the **Advanced intelligent Clear-IQ Engine (AiCE)** and offers 4D acquisition, providing dynamic, detailed images[67].

These innovations are just a few examples of the many AI advancements revolutionizing paraclinical tests.

4. Therapeutic management:

➢ Medical Treatment and Drug discovery:

AI technologies are revolutionizing medical treatment by enhancing **drug discovery** and **personalized medicine**. AI algorithms can analyze vast datasets to **identify potential drug candidates** and **predict patient responses to treatments**, leading to more effective and tailored therapies[68].

Insilico Medicine®:

A biotechnology company founded in the United States, that leverages artificial intelligence to revolutionize **drug discovery and development**. By combining genomics, big data analysis, and deep learning, Insilico Medicine® accelerates the **identification of novel drug candidates and optimizes clinical trials**[69].

Their generative AI platform, Pharma.AI, significantly reduces the time and cost required to bring life-saving medications to the market, making it a leader in the field of Insilico® drug discovery[69].

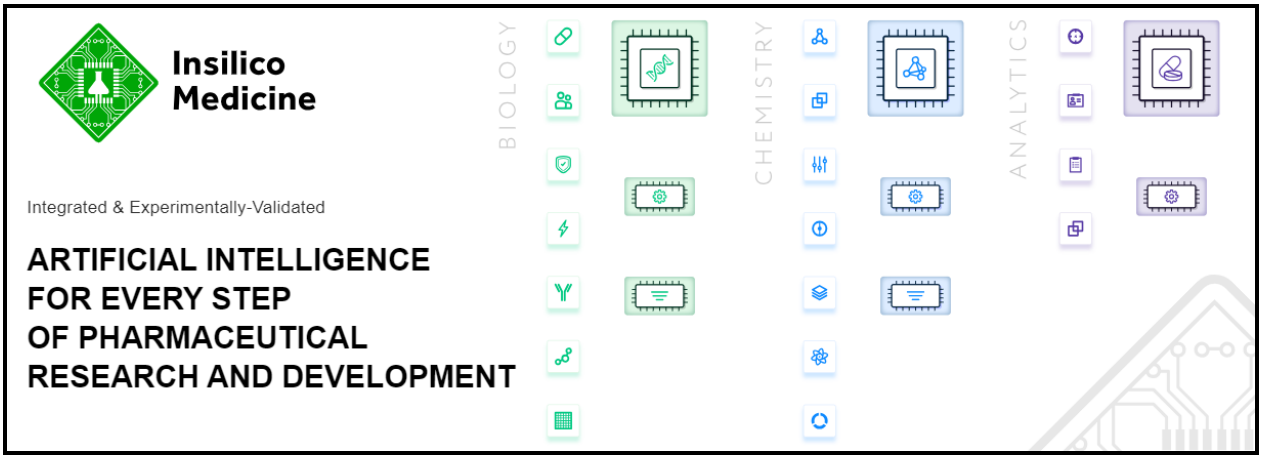

Figure (44): Screenshot from Insilico Medicine® Website[69].

- **Advancing AI-Driven Drug Discovery through Early Protein Modeling:**

Stanford **professor Michael Levitt**, PhD, a member of Insilico® Medicine's Scientific Advisory Board, won the **Nobel Prize in Chemistry in 2013** for his groundbreaking work in protein structure and protein folding using computer modeling[70]. He describes how the research he initiated over 50 years ago has been profoundly enhanced by significant advancements in computer speed and the remarkable developments in machine learning[71]. At Insilico®, AI has been trained to excel in its core strengths: processing vast amounts of data from multiple components to identify new targets and discover novel molecules. This innovative approach combines protein modeling with cutting-edge techniques in drug discovery, paving the way for groundbreaking advancements in the field.

- **AlphaFold®**, developed by DeepMind Technologies in collaboration with Insilico®, is a groundbreaking AI system designed **to predict protein structures** with remarkable accuracy. Launched in 2020, AlphaFold® represents a significant advancement in computational biology, using deep learning techniques to solve the long-standing challenge of protein folding[72].

The system's ability to accurately predict the **3D structures of proteins** from their amino acid sequences has profound implications for biomedical research. It accelerates drug discovery by helping scientists understand how proteins interact with potential drug molecules, aids in designing new therapeutics, and enhances our comprehension of various diseases linked to protein misfolding[72].

AlphaFold's impact extends across multiple fields, from molecular biology and pharmacology to personalized medicine and genetic research.

An example of a protein where AlphaFold's predictive capabilities can be particularly impactful is the **hemoglobin subunit gamma-1**, which plays a key role in oxygen transport and is essential for understanding various hemoglobinopathies[73].

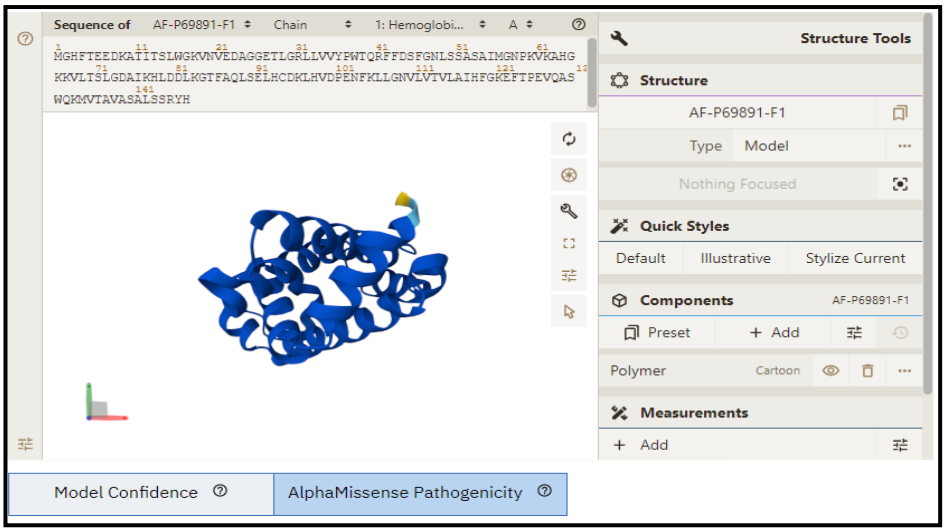

Figure (45): 3D structure of the hemoglobin subunit gamma-1 with its protein chain[73].

- **Surgical Treatment:**

AI is transforming surgical procedures through **advanced imaging and robotic assistance**. AI-powered surgical robots can perform precise and **minimally invasive surgeries**, **reducing recovery times** and improving patient outcomes. Additionally, AI-driven **preoperative** planning and **intraoperative** guidance enhance surgical accuracy and safety[74].

- **Da Vinci® Robotic-Assisted Surgery:**

The da Vinci® Surgical System by **Intuitive Surgical®** is a pioneering robotic surgical platform that enhances surgical precision and minimizes invasiveness. By translating a surgeon's hand movements into precise, real-time motions of miniaturized instruments within the patient, the da Vinci system offers superior control and dexterity. Its 3D high-definition vision system provides unparalleled clarity, enabling surgeons to perform complex procedures through small incisions[75].

The **AKDITAL** group has recently acquired the **Da Vinci Xi** robot, marking a first in Morocco. This acquisition positions the group as the leading entity in the healthcare sector to integrate this fourth generation of surgical robot, symbolizing a significant advancement in the field of robotic-assisted surgery in Morocco. However, it is important to note that this generation is not powered by artificial intelligence as the latest[76].

The latest AI-supported device in the Da Vinci® Surgical System lineup is the **Da Vinci 5**. This advanced robotic surgical system incorporates AI feedback systems, including **"Force Feedback" technology**, which allows surgeons to sense tissue tension and enhances their precision and control during procedures[75].

The Da Vinci 5 also features over 150 design innovations and significantly more computing power compared to previous models, enabling continuous evolution through software updates and enhanced capabilities[75].

Figure (46):
Last Generation of Da Vinci® Surgical Robotics with Force Feedback Technology (DaVinci 5)[75].

- **Leica Microsystems®**

Leica Microsystems® offers AI applications in surgery through their **Augmented Reality (AR) Assisted Navigation system**. This technology enhances neuro-oncological and ophthalmic surgeries by providing real-time, augmented information during procedures[77]. Surgeons can visualize critical structures, plan precise surgical trajectories, and perform accurate tumor resections while minimizing damage to surrounding healthy tissues[78].

The system includes functions like **Glow400**, which improves fluorescence imaging, and **MyVeo**, which provides personalized visualization options for enhanced decision-making. This integration of **AI and AR** significantly improves surgical precision and patient outcomes[78].

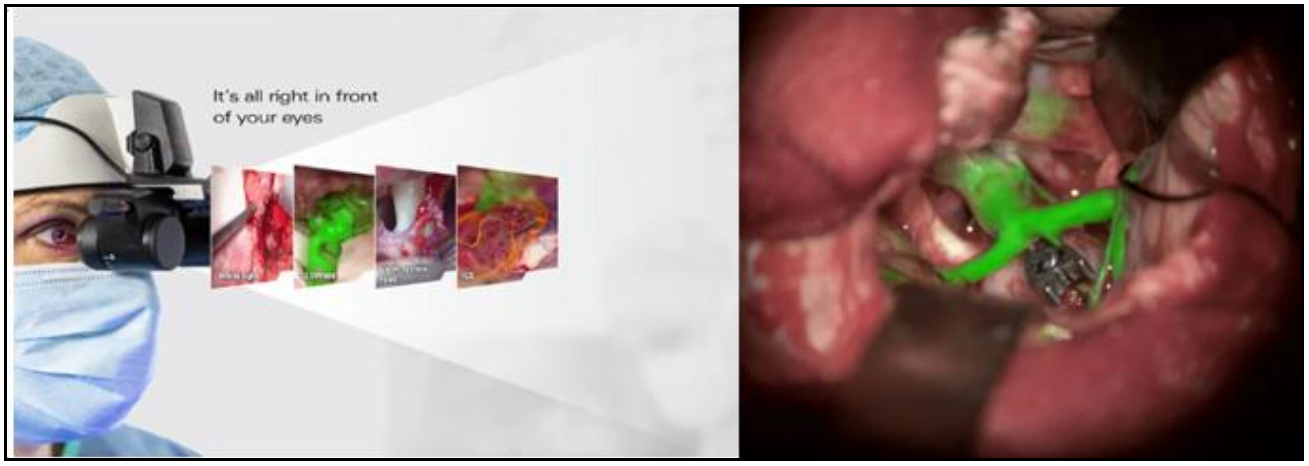

Figure (47): MyVeo Headset using Glow400 in NeuroSurgery in aneurysm repair[78].

- **Radiotherapy:**

AI is making significant strides in radiotherapy by **optimizing treatment plans** and improving **targeting accuracy**. AI algorithms can analyze patient data to customize **radiation doses**, **minimizing damage** to healthy tissues while maximizing the impact on cancerous cells. This precision leads to better treatment outcomes and **reduced side effects**[79].

- **ART-Plan® from TheraPanacea®**

An innovative AI-powered platform is designed to enhance the planning and delivery of radiotherapy treatments. By leveraging advanced AI algorithms, ART-Plan® enables **precise contouring** of anatomical regions on **3D images, automates the delineation of organs at risk, and calculates the effective dose tailored to each patient**. This facilitates adaptive radiotherapy and ensures optimal treatment efficacy and safety[80].

This platform integrates multi-modality biomarker discovery, improving the accuracy and efficiency of treatment plans. ART-Plan® supports personalized and effective cancer care by optimizing the entire treatment process, from preparation to follow-up[80].

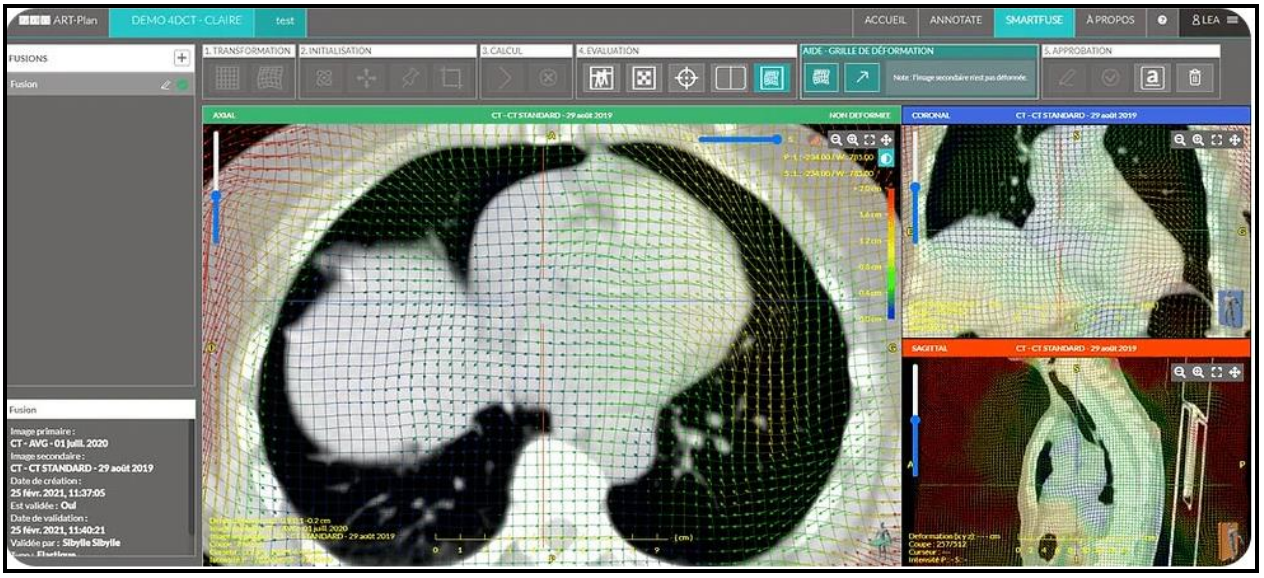

Figure (49): ART-Plan® SmartFuse Function for Real-time deformation of contours[80].

5. Monitoring and follow-up of patients:

- **Care.ai®**

Care.ai® provides an AI-driven **patient monitoring solution** designed to improve care efficiency and ensure patient safety. Their Smart Care Facility Platform employs **ambient intelligent sensors** to continuously monitor patients and vital processes in healthcare settings[81].

Real-time monitoring enables physicians to make quicker, more informed decisions, reducing response times and potential risks. Additionally, the platform supports protocol adherence and automates processes, ensuring high standards of care and compliance[81].

An illustrative example **is Care.ai's Smart Patient Rooms**, which transform healthcare settings by integrating AI and ambient intelligent sensors.

These rooms are designed to be "self-aware," continuously monitoring patients and vital processes. The AI-assisted system provides real-time data analysis, enabling proactive care and timely interventions. This technology supports clinical and operations teams, ensuring protocol adherence, patient safety, and overall healthcare efficiency. Smart Patient Rooms exemplify how AI can create a more responsive and personalized healthcare environment[81].

some key functions of Care.ai®'s Smart Patient Rooms[81]:

- **Fall Prevention**:

Sensors detect early indicators of potential bed exits, such as restless or agitated behavior, and summon help promptly.

- **Pressure Injury Avoidance**:

The system continually monitors a patient's position in bed, alerting the Smart Care Team when rotation is needed.

- **Elopement Prevention**:

Sensors monitor activity throughout the facility, notifying staff if a patient moves toward an exit or pasts a defined boundary.

- **Protocol Adherence**:

Sensors track adherence to prescribed workflows, with the Smart Care Facility Platform sending reminders to notify team members when protocols deviate from expected norms.

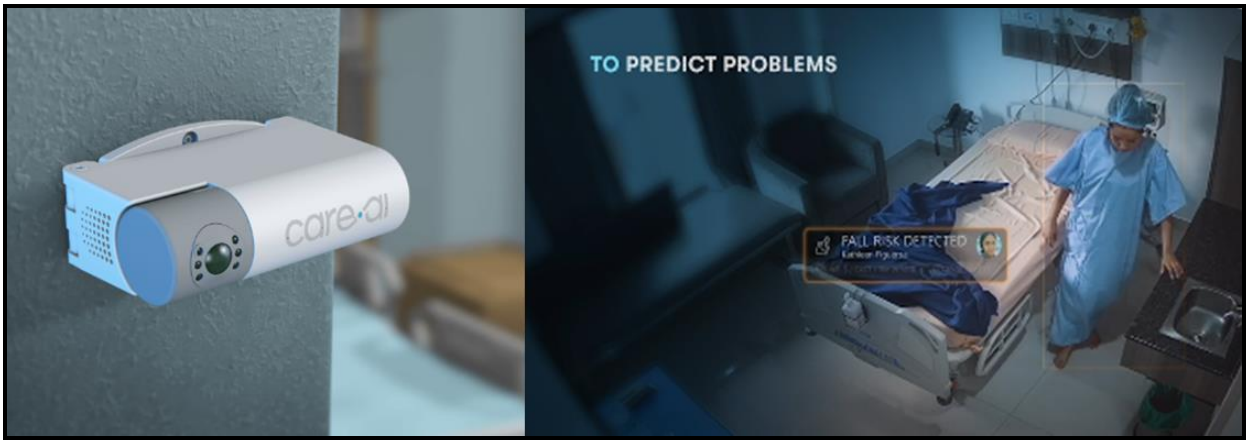

Figure (50):
Care AI® ULTRA Autonomous Monitoring Sensor used to detect fall risk based on patient movements and behavior[81].

6. Screening tests:

- **SkinVision® in Screening for Skin Cancer**

SkinVision® is an innovative AI-powered application designed to enhance the **early detection of skin cancer**. By utilizing advanced machine learning algorithms, SkinVision® transforms a smartphone into a tool capable of analyzing skin lesions with high accuracy. Users can take photos of their skin spots, which are then assessed by the AI algorithm to provide a risk

assessment within seconds. This technology is clinically validated and regulated, **offering significant sensitivity in detecting common skin cancers**[82].

The integration of AI with dermatological expertise enables SkinVision® to offer personalized skin health advice and recommendations. It supports users in monitoring their skin over time, identifying changes, and determining when professional medical consultation is necessary. By making skin health monitoring more accessible and efficient, SkinVision® plays a vital role in the early detection and prevention of skin cancer, ultimately improving patient outcomes[82].

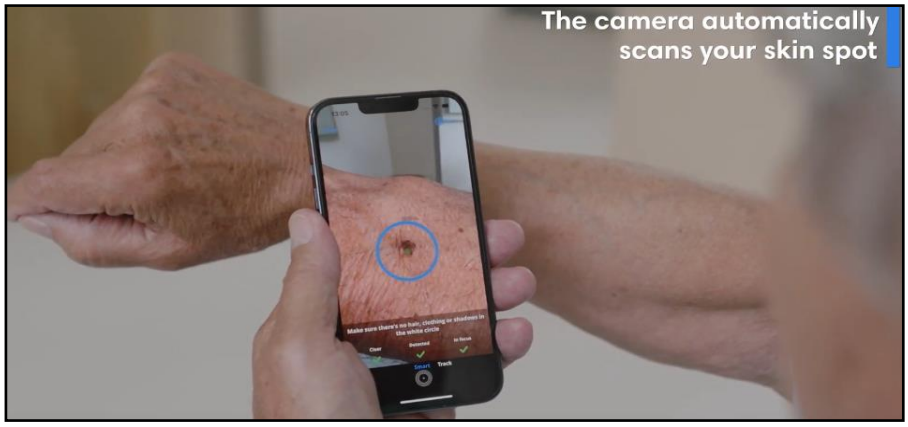

Figure (51): Real Time Skin Health Analysis with SkinVision® AI [83].

- **ARDA® in Screening for Retinopathy**

AI is transforming the screening and early detection of diabetic retinopathy. A notable example is **Automated Retinal Disease Assessment (ARDA) by Google Health®**, which utilizes AI algorithms to analyze retinal images and accurately detect signs of the disease[84].

This technology enables efficient screening of large populations, especially in areas with limited access to ophthalmologists.

AI-based tools like ARDA® often achieve diagnostic accuracy that rivals or exceeds that of human graders, enhancing the accessibility and reliability of **early retinopathy detection**. By automating the screening process, these systems help **prevent vision loss and blindness in patients with diabetes**, facilitating timely intervention and treatment[85].

Figure (52): ARDA® Screening Diabetic Retinopathy Grade 01[85].

- **MammoScreen® AI in Screening for Breast Cancer:**

MammoScreen® AI is an advanced software designed to assist radiologists in **breast cancer screening**. The system analyzes both 2D and 3D mammograms to identify suspicious regions and evaluate their probability of malignancy. By providing a second assessment, MammoScreen aids radiologists in confirming findings and ensuring that nothing is overlooked[86].

This technology enhances the accuracy and efficiency of breast cancer screening, leading to earlier detection and improved patient outcomes[86].

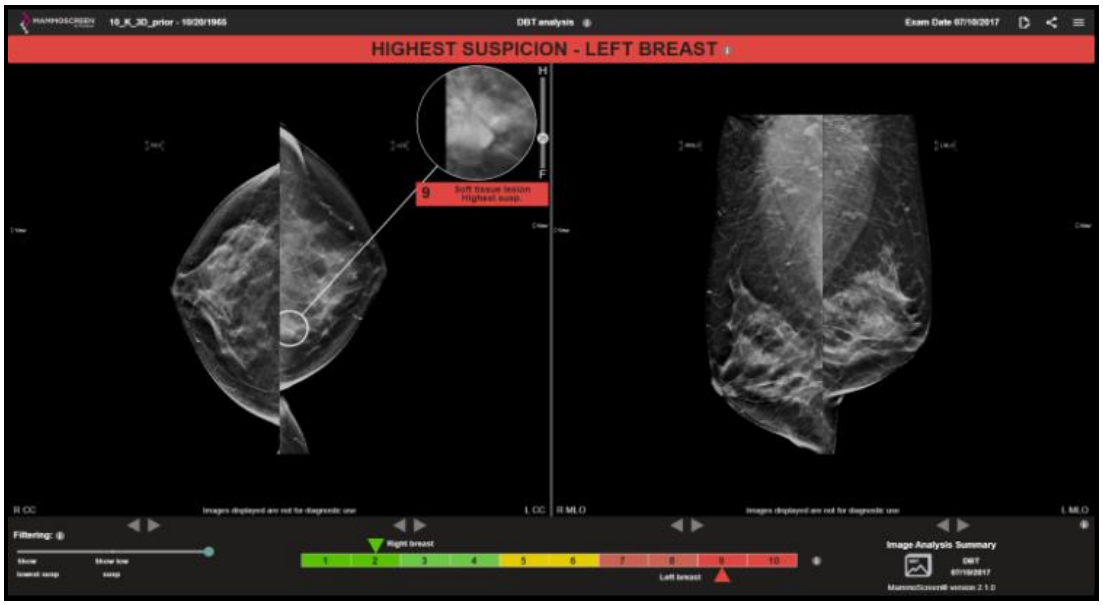

Figure (53): MammoScreen® Dashboard Detecting a Highly Suspicious Lesion in the Left Breast[86].

II. Ethical Challenges in AI Implementation:

Ethics, in philosophy, is defined as the study of the foundations of morality. It also refers to a set of rules of conduct. In medicine, it corresponds to the rules of conduct that physicians must follow in relation to their patients. It is the cornerstone of medical deontology and the Hippocratic Oath[87].

Ethical reflection on the use of artificial intelligence in medical practice is a fundamental element. It serves as a guide for developers, manufacturers, users, and regulators. This reflection will help mitigate risks and maximize opportunities related to its use. It will also prompt discussions on issues such as the decision-making power of AI regarding end-of-life care[88].

Many of these ethical questions are not purely specific to the healthcare domain. This is evident in the development of concepts like **trust, responsibility, autonomy, and data**. The participants in our study extensively addressed ethical questions, both directly and indirectly. Some expressed concerns regarding the adherence to certain principles, such as **human autonomy and equity**. Others mentioned measures to facilitate the introduction of AI in medical practice that aligned with ethical principles, such as the necessity for **transparency** toward patients[89].

The World Health Organization (WHO), through its report titled *Ethics and Governance of Artificial Intelligence for Health*, has put forward **six guiding principles** related to the design and use of AI[90]:

- **Protect human autonomy**
- **Promote the well-being and safety of individuals, as well as the public interest**
- **Ensure transparency, clarity, and comprehensibility**
- **Encourage accountability and responsibility**
- **Ensure inclusion and equity**
- **Promote responsive and sustainable AI**

On the other hand, **the European Commission** established a high-level independent **expert group on artificial intelligence to draft ethical guidelines for trustworthy AI**. The diagram below summarizes the requirements that seem to be the most important and which we have largely addressed in this discussion. These requirements encompass ethical, legal, and technical aspects of artificial intelligence[91].

Figure (54): The 7 key requirements for trustworthy AI and their relationships[92].

III. Discussion of findings:

1. Physicians Survey:

1.1 Summary and Interpretation of Results

Our sample predominantly consisted of general practitioners working in urban settings. The vast majority (60%) were under the age of 35. The sex ratio was 0.8, with a majority of female practitioners. The median number of years in practice was 4 years, and their activity primarily ranged from 15 to 50 consultations per day.

Regarding computer literacy levels, the majority of physicians (59%) reported feeling comfortable with their computer usage skills. While a significant proportion of physicians have permanent access to internet-enabled computers that facilitate the integration of AI tools (40%), this access remains insufficient, as a majority (60%) continue to encounter difficulties in accessing essential digital tools. This reveals substantial barriers to the adoption of AI in clinical settings and underscores the urgent need for advancements in healthcare infrastructure in Morocco.

A substantial majority of physicians, comprising 74%, exhibited limited knowledge or even a complete lack of knowledge regarding AI technologies. This indicates another significant barrier to the effective integration of AI in medical practice and highlights the need for targeted educational initiatives to enhance understanding and utilization of these technologies.

The majority of physicians occasionally engaged with AI technologies in their medical practice, with the dominant tools being ChatGPT® and PocketDoc®, along with other interesting tools such as medication prescription support and automated ECG interpretation.

Concerning confidence levels, A significant portion of physicians felt slightly to moderately confident in AI's ability to make medical decisions autonomously, indicating that Moroccan physicians appear cautiously optimistic about the autonomy of AI in clinical practice.

A significant proportion of physicians (41%) expressed concerns about potential negative reactions from Moroccan patients regarding the use of AI in medical practice. This indicates a

need for addressing patient education and acceptance to facilitate the integration of AI in medical practice.

The perceptions of physicians regarding AI's influence on the physician-patient relationship were almost evenly divided between negative and positive influences, with a minority believing there is no influence at all. This highlights a varied perspective on AI's role in medical interactions.

Concerning data confidentiality, the majority of physicians expressed concerns about the confidentiality of medical data when using AI. This indicates a strong awareness of the potential risks and challenges associated with ensuring robust data security measures, particularly regarding data breaches and unauthorized access to sensitive patient information.

However, they also believe that AI will decrease the risk of medical errors by helping to identify patterns and alert physicians to potential issues that may be overlooked in traditional practices. Additionally, most physicians believe that AI could increase access to specialized healthcare in remote regions. They contend that AI can help overcome geographic barriers by connecting patients in underserved areas with specialists through virtual consultations and AI-assisted tools, ultimately improving health outcomes.

Concerning the primary hopes and concerns of physicians in medical practice: medical imaging analysis, electronic health record management, and remote patient monitoring were identified as the three most useful applications of AI. Additionally, among other concerns, the loss of the human aspect and empathy in interactions, confidentiality and security of medical data, and insufficient training and knowledge among physicians regarding AI were highlighted as the three principal challenges encountered by practitioners.

In the section regarding the impact of AI on the professional lives of physicians, where we discussed concerns about AI potentially replacing medical tasks: the concerns about AI replacing multiple medical tasks, repetitive and administrative tasks or minimal replacement of medical tasks and the belief that AI will not substitute critical medical roles were evenly distributed among physicians, reflecting a varied perception of the role of AI in their professional practice.

Despite these concerns, the majority of physicians believe that the integration of AI will help reduce their workload. This suggests a strong positive outlook toward AI as a tool that could alleviate some of the administrative or routine tasks currently burdening physicians, allowing them to focus more on patient care and clinical decision-making.

Concerning AI's impact on professional responsibility in medical practice, half of the surveyed practitioners believe that AI will necessitate a shared responsibility between physicians and AI developers. This shared responsibility underscores the importance of ongoing dialogue between physicians and technologists to address potential risks and enhance the overall quality of care.

Additionally, half of the surveyed physicians believe that the integration of AI would enhance their professional satisfaction. This suggests that physicians see AI as a way to reduce administrative burdens and improve efficiency, allowing them to focus more on patient care and find greater fulfillment in their work.

Regarding the most relevant question in the survey: Opinions on the increased integration of AI in medical practice, over half of the participants expressed their support for this integration. This demonstrates a strong willingness among physicians to embrace AI as a valuable tool that can enhance healthcare delivery, improve efficiency, and ultimately benefit patient outcomes.

Finally, the last question of the survey evaluated intentions to pursue further education on AI in medicine, with nearly all surveyed physicians expressing a strong intention to enhance their understanding of AI and its applications in the medical field.

2. Moroccan Patients Interview:

2.1 The Vital Role of Emerging Technology Awareness for Moroccan Patients:

Artificial intelligence has been a focal point of interest for several years, making it crucial for the Moroccan population to be well-informed about its diverse applications, especially in the medical field. As AI technology evolves rapidly, understanding its potential benefits and challenges is essential for leveraging it effectively.

In our study, while participants generally demonstrate a foundational awareness of artificial intelligence, their understanding is often limited and lacks depth.

Educational initiatives, community workshops, and public awareness campaigns can significantly enhance knowledge about AI. By engaging with experts, fostering discussions, and providing accessible resources, we can empower individuals to recognize how AI can improve healthcare outcomes.

Informed citizens will be better equipped to navigate the implications of AI, advocate for ethical practices, and contribute to a future where technology and human well-being coexist harmoniously. Let's prioritize education and awareness to ensure that everyone in Morocco can actively participate in the AI-driven transformation of our society.

2.2 Generational Perspectives: The Challenge of AI Acceptance in Society:

The impact of the generational gap on AI acceptance in society is a complex issue that shapes how different age groups perceive and interact with artificial intelligence. Older generations often exhibit skepticism or apprehension toward new technologies, largely due to a lack of familiarity and a tendency to value traditional methods. This hesitation can come from concerns about profession displacement, privacy issues, and the ethical implications of AI, leading to resistance in embracing its benefits[93].

This concept of "generational issues" frequently emerged during our discussions. Some individuals expressed concerns that artificial intelligence (AI) may be feared and misunderstood by older generations who have not been immersed in technology from a young age. However, contrasting perspectives can be found in the literature. For instance, a study conducted by Chinese researchers on AI in healthcare suggests that older demographic groups maybe more open to the integration of AI in health services. This is likely due to their higher prevalence of chronic illnesses and greater healthcare needs. Consequently, the availability of more accessible and cost-effective care represents a significant concern for this population[94].

In contrast, younger generations tend to be more open and adaptive to technology, having grown up in a digital world where AI is increasingly integrated into everyday life. They often view AI as a tool that can enhance efficiency, improve decision-making, and create new opportunities.

This generational perspective fosters a greater willingness to experiment with and advocate for AI applications across various fields, including healthcare, education, and entertainment.

The divergence in attitudes towards AI can create a rift in societal acceptance and implementation. For instance, older adults may hesitate to use AI-driven healthcare solutions, while younger individuals readily adopt telemedicine and AI-based diagnostics as it was indicated in our study. Bridging this gap requires targeted education and outreach efforts that address the specific concerns of older generations while promoting the advantages of AI to build trust and understanding.

Ultimately, fostering intergenerational dialogue about AI can help harmonize perspectives, ensuring that society can fully leverage the benefits of this technology while addressing the fears and reservations of those less inclined to embrace it. By cultivating a shared understanding, we can create an inclusive environment where AI is viewed as a collaborative tool for progress, benefiting all age groups.

2.3 Infrastructural Obstacles in the Moroccan Health System.

The Moroccan health system faces several infrastructural obstacles that hinder the implementation of artificial intelligence (AI). One of the primary challenges is the digital infrastructure gap; many rural areas in Morocco lack access to high-speed internet and even basic computerization, which are essential for effective medical practice and for deploying AI technologies in the future. This digital divide limits healthcare facilities' ability to leverage new technologies.

From the study conducted, we found that the majority of physicians continue to face significant challenges in accessing these essential digital tools. This issue was emphasized in both the survey and patient interviews, where participants voiced concerns regarding the Moroccan infrastructure and funding for AI implementation.

These insights highlight the urgent need for enhancements in digital resources and increased investment to enable the effective integration of AI into the Moroccan healthcare system.

Morocco must allocate more of its GDP to healthcare, as the current investment of approximately 5.3% is considerably lower than the 9-11% average in Euro-Mediterranean countries[95]. Increasing this investment is crucial for enhancing the availability of funds needed for advanced AI technologies and developing a robust digital health infrastructure.

Morocco must significantly increase its focus on research and development in healthcare, particularly in artificial intelligence. Currently, the country has fewer AI-focused research publications compared to nations such as France[95], highlighting a gap in research capacity and output. By fostering a more robust research environment and encouraging collaboration between academic institutions and the healthcare sector, Morocco can enhance its innovation potential and contribute more effectively to advancements in healthcare technology.

2.4 AI Promises in Addressing Public Expectations:

Our study revealed that, beyond its applications in healthcare, the participants perceived benefits from its use in everyday life. We investigated the expectations of our participants regarding the implementation of AI. A significant portion of them believed that the advancement of AI in medical practice is driven not only by the advantages it offers in this field but also by the increasing demands of the population on the healthcare system.

In our study, the expectations expressed by the population pertained to enhancements in the capabilities and performance of both medicine and surgery. This includes support for diagnosis, interpretation of imaging studies, robotic-assisted surgery, and contributions to research and genetics, among others.

There is a scarcity of literature addressing the articulation of public expectations regarding the use of AI in healthcare. However, one notable study, a Sino-American collaboration from 2019 titled "Implementation of artificial intelligence in medicine: Status analysis and development suggestions," highlights certain expectations, such as improvements in diagnostic performance and the interpretation of imaging studies. We observe that there are notable similarities in these findings[96].

2.5 Training Future Moroccan Practitioners in New Technologies:

The rapid advancement of technology, particularly in artificial intelligence (AI), presents both challenges and opportunities for the healthcare sector in Morocco. As the demand for skilled professionals who can effectively leverage these technologies grows, it becomes imperative to enhance the training of future practitioners. This training must not only encompass the technical skills required to utilize AI technologies but also emphasize their application in real-world healthcare settings[97].

The study conducted revealed that nearly all surveyed physicians expressed a strong intention to deepen their understanding of AI and its applications in the medical field. Additionally, interviews with patients indicated a growing demand for improved education and training for future physicians, underscoring the critical need for comprehensive programs that integrate these emerging technologies.

A research study conducted in the Department of Radiology at the University Hospital Cologne in Germany assessed undergraduate medical students' attitudes towards artificial intelligence (AI) in radiology and medicine[98]. The findings revealed that over two-thirds of the students (71%) agreed on the necessity of incorporating AI into medical training. Sub-group analyses indicated that male students and those with a greater familiarity with technology expressed more confidence in the benefits of AI and exhibited less fear regarding these technologies. This highlights the importance of fostering technological literacy among medical students to promote a positive outlook on the integration of AI in medical practice.

To achieve this, academic institutions must collaborate with healthcare organizations and technology developers to create curricula that reflect current trends and future needs. This includes hands-on training, internships, and workshops focused on AI applications in healthcare. Additionally, continuous professional development programs should be established to ensure that current practitioners remain updated on emerging technologies.

Investing in the training of future Moroccan practitioners in new technologies, will not only enhance individual competencies but also strengthen the overall healthcare system. By

embracing innovation, Morocco can improve health outcomes and position itself as a leader in the integration of technology in healthcare.

3. Literature Review:

3.1 Physicians Survey:

The integration of artificial intelligence (AI) in medical practice is becoming increasingly important globally, yet there's a noticeable lack of research on this topic in Morocco. This literature review aims to fill that gap by exploring the views of Moroccan practitioners regarding AI in their clinical practices.

While similar studies are limited worldwide, one noteworthy exception is Dr. Moukrim's 2019 research in Marseille, which assessed general practitioners' attitudes toward AI. It revealed that many physicians expected a positive impact from AI on medical practice[99].

What sets our study apart is its specific focus on the Moroccan healthcare context. It offers valuable insights into the current state of AI adoption in Morocco and contrasts these findings with the international context, contributing to the broader discussions on AI implementation in medical practice from both regional and global viewpoints.

- **Sample Characteristics**

Both our study and Dr. Moukrim's research primarily involved younger physicians, with our study featuring 60% of participants under age 35, while the Marseille study reported 79% in that age group. Our research concentrated on general practitioners in urban settings, whereas the others included substitute physicians from both urban and semi-rural locations. The gender distribution also varied: our study had a female-to-male ratio of 0.8, while the other reported a ratio of 0.65, with a majority of female participants.

Both studies reflected a relatively young cohort in terms of years of practice, with median experience of 4 years in our research and 2 years in the other.

- **Digital Literacy and Access**

Our findings highlighted significant challenges regarding digital access, with 60% of physicians struggling to access essential digital tools, even though 59% felt comfortable with their computer skills. In contrast, the other study reported high levels of computer literacy, with

nearly all respondents working in computerized environments. This suggests that while individual skills may be adequate, infrastructural barriers persist in our study's context.

- **Knowledge and Use of AI**

A considerable lack of AI knowledge among physicians was evident in both studies. In ours, 74% had limited or no awareness of AI technologies, mirroring the findings from the other study, where a majority also lacked AI knowledge by 88%. Additionally, few participants in both studies had practical experience with AI, indicating that insufficient knowledge and exposure are significant obstacles to AI adoption.

- **Perceptions of AI on Physician-Patient relationship**

Physicians in both studies expressed mixed feelings about AI's influence on clinical practice. In our research, 41% were concerned about potential negative reactions from patients toward AI, a sentiment echoed in the other study, which reported similar opinions, with a predominance of neutral reactions. Perspectives were divided on how AI might affect the physician-patient relationship; in our study, 45% indicated a negative impact, while over 50% in the other study shared the same view. Some physicians saw potential benefits, while others feared that AI might undermine human interaction.

- **Data Confidentiality**

Our study specifically raised concerns about the confidentiality of medical data in AI applications, showing a strong awareness of the associated risks and the necessity for robust data security. The other study did not emphasize data confidentiality, focusing more on general perceptions of AI's impact on clinical practice.

- **Hope and Concerns**

Both studies identified promising areas where AI could enhance medical practice, such as in diagnostics and uncertainty management. Our research pointed to applications like medical imaging analysis, electronic health record (EHR) management, and remote monitoring. However, concerns remained prominent, including the potential erosion of the human aspect of care, data security risks, and inadequate AI training for physicians.

- **Impact on Workload and Responsibility**

Our findings indicate that 68% of physicians believe AI could alleviate their workload. The other study did not specifically focus on this aspect but noted that 56% of respondents believe AI will positively impact their time management. Regarding professional satisfaction, our study found that 51% of participants believe AI will enhance their job satisfaction, while 36%, the largest percentage, indicated that AI has no effect on their professional satisfaction in the other study.

An article by Dr. Chang Min Park, a professor in the Department of Radiology at Seoul National University in Korea, discusses the same point, 'AI: Workload Reduction by Autonomous Reporting of Normal Chest Radiographs.' His research focuses on AI technology for radiologic imaging and highlights the potential of artificial intelligence to alleviate the growing workload in radiology, especially considering the ongoing shortage of radiologists[100].

As the demand for imaging continues to rise, AI can autonomously identify and report normal chest radiographs, effectively filtering out routine cases. This capability streamlines workflows and allows radiologists to concentrate on more complex cases, ultimately improving efficiency and reducing burnout. The integration of such AI technologies could be a vital step in addressing the challenges currently facing the field of radiology[100].

- **Overall Assessment of AI Support in Medical Practice**:

Despite mixed perceptions and concerns, both studies found a majority of physicians supportive of AI development and integration in clinical practice. In our study, 56% of physicians expressed support for AI implementation, closely aligning with Dr. Moukrim's study, which found 57% in favor. These findings indicate a growing recognition among physicians of the potential benefits that AI can bring to medical practice on a global scale.

3.2 Patients interview:

In the literature review, a significant research study conducted in France by Dr. Rémi Calmon and Dr. Ravin Ibrahim Kacem examines the expectations and concerns of the general population regarding the use of artificial intelligence in medicine[101]. Their findings provide valuable insights into how the public perceives AI's potential to enhance medical practice while

also highlighting apprehensions related to privacy, data security, and responsibility concerning AI within the medical field.

In comparison with our study, the sampled French population interviewed appeared to be slightly more aware of artificial intelligence. Some participants demonstrated this awareness by providing definitions of AI that were approximately correct, reflecting a better understanding of its applications and implications in healthcare.

This heightened awareness may be attributed to ongoing public discussions and educational initiatives surrounding AI technologies in France, contributing to a more informed perspective among certain individuals regarding the role of AI in medical practice.

This should encourage Moroccan institutions to enhance public education and awareness initiatives surrounding artificial intelligence in healthcare. By fostering a better understanding of AI among the population, institutions can help alleviate concerns and promote informed discussions about its potential benefits and challenges.

The interviews with patients revealed that key points largely aligned with those identified in the French research, particularly regarding concerns similar to those expressed by the Moroccan population studied.

These concerns included issues related to the security and confidentiality of digital medical records, apprehensions about AI malfunctions and also skepticism toward AI in critical medical procedures, and most importantly, ethical concerns regarding the right to transparency in AI usage. However, the French participants did not express significant concerns about infrastructure and funding, likely due to ongoing developments and improvements in healthcare infrastructure in France.

Regarding hopes, the French population expressed a desire for advancements across all areas of medical practice, demonstrating a cautious optimism about AI's potential. They emphasized the need for patient education on AI and highlighted the expectation that younger physicians will take the lead in integrating this new technology into medical practice. This alignment underscores the importance of understanding societal attitudes as AI technologies are integrated into healthcare settings.

IV. Strengths and limitations of the study:

1. Physicians Survey

- **Strengths of the Study:**

The central focus of our study lies in the addressed theme, which represents an original contribution to a significant subject. While artificial intelligence is frequently highlighted, its exploration within the field of medicine remains limited.

The descriptive analysis, particularly through the questionnaire assessing physicians' opinions on the potential impact of AI on their practice, has revealed notable trends. Specifically, the low number of "no opinion" responses indicates genuine interest among physicians in this topic.

Furthermore, the responses related to the primary judgment criterion demonstrated a clear majority in favor of the development of AI in medical practice, underscoring the growing enthusiasm for this technology within the profession.

This enthusiasm not only reflects a willingness to embrace innovation but also highlights the potential for AI to enhance patient care and improve clinical outcomes. As the medical community becomes more engaged with AI, it paves the way for a transformative shift in how healthcare is delivered, ultimately benefiting both practitioners and patients.

- **Limitations of the Study:**

One of the limitations of the study was the lack of representativeness of the sample from the target population. This limitation was particularly evident in terms of age and practice type. Specifically, 60% of the physicians in our sample were under the age of 35, and nearly half of the participants were general practitioners, with 27% being internal medicine physicians. This phenomenon may be attributed to a selection bias resulting from the method of questionnaire distribution, which predominantly reached a higher proportion of these practitioners, who are generally younger than the average. Additionally, it can be inferred that younger individuals may have a greater interest in the subject matter.

A further limitation of our study was the relatively low response rate, with only 200 completed questionnaires. This figure can likely be attributed to the method of questionnaire distribution, which may have constrained the reach of our research. Factors such as the distribution method, the time allocated for participants to respond, and the awareness of the topic's significance may have influenced participation levels. For future studies, it would be advantageous to investigate alternative distribution strategies to enhance the response rate and ensure a broader representation of physicians' opinions on artificial intelligence in the medical field, particularly in clinical practice.

A voluntarism bias was also evident in this study, as the physicians who took the time to respond to the questionnaire were more interested in the topic and, as a result, more likely to support the development of artificial intelligence. Furthermore, this was a descriptive study, which, while not representative, provided valuable insights into Moroccan physicians' attitudes toward the impact of AI in medical practice.

We also lacked sufficiently robust points of comparison in the literature. We identified only one example that could provide context for our study. However, a single example was not sufficient to assess the validity of our research. Unfortunately, we did not find any other studies that could be compared to ours. Hopefully, future research will explore this area more comprehensively, providing additional data and insights for comparison.

2. Patients Interview

- **Strengths of the Study**:

The selection of a qualitative methodology was considered the most appropriate for the topic, facilitating the exploration of subjective phenomena. This approach enabled participants to express themselves freely and articulate their perspectives.

The execution of this research represented a significant strength, as it contributed to minimizing subjectivity in the analysis by ensuring rigor throughout the process. Each phase of the research was conducted systematically, from coding to modeling, thereby maintaining a coherent and organized approach.

A notable variability among participants was observed regarding age and gender. Overall, the diversity of selection criteria was upheld, which allowed for the inclusion of a range of profiles during the study.

Finally, this research adhered to the COREQ criteria, thereby ensuring optimal quality and transparency in the qualitative investigation[102].

- **Limitations of the Study:**

The first limitation of this part of the study lies in the lack of experience with qualitative methodology. Prior to conducting this research, there had been no participation in studies of this nature. Training was undertaken through the reading of specialized literature on the subject.

A significant limitation of this study is that it was conducted by a single researcher, which does not fully align with the COREQ (Consolidated criteria for reporting qualitative research) guidelines that recommend the involvement of at least two researchers to facilitate triangulation and enhance credibility. While we aimed to follow the COREQ criteria as closely as possible, the limitation of having only one researcher may affect the robustness of the findings and introduce potential biases. To address this, efforts were made to ensure reflexivity and to seek peer feedback during the analysis process.

Conducting a semi-structured interview requires a certain level of experience. The management of silences, prompts, and reformulations essential for deepening the expressed ideas was not always executed optimally. However, improvements were noted, and the quality of this management refined over the course of the interviews.

It is also important to highlight the social desirability bias that affects most studies in the social sciences. Respondents may be inclined to provide answers that present them favorably in the eyes of the researcher. This bias can significantly impact the interpretation of the results.

The professional diversity bias is another factor to consider in this study, arising from the inclusion of various professions. This variety can influence participants' responses, as each profession has distinct expectations and perceptions. Additionally, another bias to consider is confirmation bias, which may occur if participants tend to affirm their own beliefs or experiences

rather than provide objective responses. Together, these biases emphasize the importance of careful analysis of the collected data to ensure accurate interpretation of the results.

Finally, the sample includes a limited number of individuals with chronic medical conditions, indicating that there are few participants with high expectations of the healthcare system. This selection bias may affect the analysis of the results.

CONCLUSION

In an era marked by rapid technological advancement, artificial intelligence emerges as a double-edged sword, presenting both profound opportunities and significant challenges. Its integration into our society, particularly within the healthcare sector, is a topic of fervent debate. In medical practice, AI evokes a complex interplay of fears and hopes among both physicians and patients. While its potential to enhance healthcare systems is undeniably attractive, it also brings with it a host of risks that cannot be overlooked. As we move forward, thoughtful contemplation and decisive action will be essential, particularly within the Moroccan context.

This study was an original exploration of a significant yet under-researched subject in the field of medicine. It highlighted that most physicians support the integration of AI into their professional practices, while also identifying strong trends regarding their concerns and hopes related to the advancement of this technology. In doing so, it illuminates the gaps and shortcomings that must be addressed within our healthcare system, particularly highlighting the infrastructural fragility often reported by both physicians and patients. This underscores the necessity for improvements at the foundational level of the system before fully embracing a new technological landscape. If left unaddressed, the rapid advancement of scientific progress risks leaving those reliant on a deficient system behind as we transition into this new era of technology.

While the modest AI tools currently utilized by physicians may be relatively simple to handle, there is an imminent need for them to prepare for more complex technologies on the horizon. This underscores the critical importance of education and training in equipping physicians with the skills necessary to navigate the evolving landscape of artificial intelligence in medicine. As we look ahead, the future of healthcare will evolve into a vibrant tapestry of multidisciplinary collaboration, weaving together the expertise of physicians, computer engineers, technicians, and other essential professionals. This integrated approach will harness diverse perspectives and skills, ensuring a holistic and innovative response to the challenges of modern medicine.

At the core of this exploration are the patients, whose expectations and concerns must be thoroughly considered. Our study highlights several factors critical for the acceptance of AI in healthcare. Foremost among these is the necessity to preserve the human aspect of the physician-patient relationship. Essential interpersonal qualities, such as empathy and active listening, cannot be replicated by machines, and patients do not envision AI replacing human doctors. They will also play a role in data sharing by embracing the concept, but it is essential to first reassure them by ensuring that this sharing occurs without any negative consequences. Practitioners, on their part, will require evidence of the effectiveness of these tools and need reassurance regarding the maintenance of their autonomy and accountability.

Moreover, it is vital to promote widespread understanding of AI while ensuring that ethical, legal, and technical standards are rigorously maintained to cultivate reliable AI systems. Our research underscores that trust plays a pivotal role in the acceptance of these innovative tools, especially within the healthcare sector.

Ultimately, it is crucial to ensure that patients remain at the center of all decisions as AI reshapes the field of medicine. Acknowledging the limited number of studies in this area, we can pursue further research while encouraging a new generation of physicians to enhance their understanding of AI, foster curiosity, and embrace the challenges and opportunities presented by the continuously evolving technological landscape.

ABSTRACT

Abstract

INTRODUCTION: The AI revolution is making headlines worldwide, offering the potential to significantly enhance our quality of life, alongside a host of representations and fantasies surrounding it. Meanwhile, healthcare systems globally are under mounting pressure and facing increasing demands, including in Morocco. As a result, AI is seen as a promising solution to these challenges. "What are the expectations and concerns of physicians and the general population, particularly patients, regarding AI in medical practice?"

METHODS: This research is organized into two main components. The first component focuses on physicians and employs a descriptive, cross-sectional quantitative design, utilizing an opinion survey (questionnaire) to gather data. The second component addresses the general population (patients) and employs qualitative methods through semi-structured interviews. This qualitative study involves conducting individual interviews with adult Moroccan citizens, utilizing purposeful sampling and snowball recruitment techniques. Data will be analyzed using grounded theory to derive meaningful insights.

RESULTS: The first component of the study focused on general practitioners in urban settings, primarily under 35 years old, with a median of four years in practice. While most reported comfort with their computer skills, many faced challenges accessing essential digital tools, hindering AI adoption. A significant portion had limited knowledge of AI technologies, emphasizing the need for educational initiatives. Many physicians occasionally used entry-level AI tools, with mixed confidence in AI's decision-making abilities. Concerns about patient resistance and data confidentiality were prevalent, but many believed AI could reduce medical errors and improve access to care in remote areas.

Key AI applications identified included medical imaging, electronic health records, and remote monitoring. Physicians expressed varied views on AI replacing tasks but generally felt it could alleviate their workload, allowing more focus on patient care. Half believed in shared responsibility with AI developers and felt that AI could enhance professional satisfaction. Over

half supported increased AI integration in medical practice, with nearly all expressing interest in further education on AI applications.

Transitioning to the second component, the study underscores the critical need for raising awareness of AI among the Moroccan population, particularly in healthcare, where many participants demonstrated only a basic understanding. Bridging the generational gap is essential, as older individuals often express skepticism towards AI due to unfamiliarity, while younger generations are generally more accepting and see AI as a tool for enhancing efficiency.

Moreover, significant infrastructural challenges persist in the Moroccan healthcare system, including a digital divide that restricts access to essential technologies, highlighting the urgent need for increased investment and focus on AI-related research. Participants expressed expectations for AI to improve medical capabilities, aligning with broader public demands for advancements in healthcare.

Finally, enhancing training for future healthcare practitioners is vital, as nearly all surveyed physicians showed a strong interest in learning about AI applications. Collaborative efforts between academic institutions and healthcare organizations are necessary to develop relevant curricula and hands-on training, ultimately strengthening Morocco's healthcare system and improving health outcomes. Together, these findings emphasize the interconnectedness of physician education, public awareness, and infrastructure development in successfully integrating AI into Morocco’s healthcare landscape.

Résumé

INTRODUCTION : La révolution de l'IA fait les gros titres dans le monde entier, offrant la possibilité d'améliorations significatives de notre qualité de vie, tout en suscitant de nombreuses représentations et fantasmes. Dans le même temps, les systèmes de santé à l'échelle mondiale sont soumis à une pression croissante et font face à des demandes de plus en plus importantes, y compris au Maroc. L'IA est donc considérée comme une solution prometteuse pour relever ces défis. « Quelles sont les attentes et les préoccupations des médecins et de la population générale, en particulier des patients, concernant l'IA dans la pratique médicale ? »

MÉTHODES : Cette recherche est organisée en deux composantes principales. Le premier volet se concentre sur les médecins et utilise un modèle quantitatif descriptif et transversal, recourant à une enquête d'opinion (questionnaire) pour recueillir des données. Le second volet s'adresse à la population générale (patients) et utilise des méthodes qualitatives par le biais d'entretiens semi-structurés. Cette étude qualitative implique des entretiens individuels avec des citoyens marocains adultes, en utilisant des techniques d'échantillonnage ciblé et de recrutement en boule de neige. Les données seront analysées à l'aide de la théorie ancrée afin d'obtenir des informations significatives.

RESULTATS : La première composante de l'étude se concentrait sur les médecins généralistes exerçant en milieu urbain, principalement âgés de moins de 35 ans, avec une médiane de quatre ans de pratique. Bien que la plupart se déclarent à l'aise avec leurs compétences informatiques, beaucoup rencontrent des difficultés d'accès aux outils numériques essentiels, ce qui freine l'adoption de l'IA. Une part significative avait une connaissance limitée des technologies de l'IA, soulignant la nécessité d'initiatives éducatives. De nombreux médecins utilisaient occasionnellement des outils d'IA de niveau débutant, avec une confiance mitigée dans les capacités décisionnelles de l'IA. Les préoccupations concernant la résistance des patients et la confidentialité des données

étaient courantes, mais beaucoup croyaient que l'IA pourrait réduire les erreurs médicales et améliorer l'accès aux soins dans les zones rurales.

Les principales applications de l'IA identifiées comprenaient l'imagerie médicale, les dossiers de santé électroniques et la surveillance à distance. Les médecins exprimaient des opinions variées sur le remplacement de tâches par l'IA, mais pensaient généralement que cela pourrait alléger leur charge de travail, leur permettant ainsi de se concentrer davantage sur les soins aux patients. La moitié d'entre eux croyait en une responsabilité partagée avec les développeurs d'IA et estimait que l'IA pourrait améliorer la satisfaction professionnelle. La majorité soutenait une intégration accrue de l'IA dans la pratique médicale, presque tous exprimant un intérêt pour une formation supplémentaire sur les applications de l'IA.

En passant à la deuxième composante, l'étude souligne le besoin crucial de sensibiliser la population marocaine à l'IA, en particulier dans le domaine de la santé, où de nombreux participants n'avaient qu'une compréhension basique. Il est essentiel de combler le fossé générationnel, car les personnes âgées expriment souvent un scepticisme envers l'IA en raison de leur manque de familiarité, tandis que les jeunes générations sont généralement plus acceptantes et voient l'IA comme un outil pour améliorer l'efficacité.

De plus, des défis infrastructurels importants persistent dans le système de santé marocain, notamment un fossé numérique qui limite l'accès aux technologies essentielles, soulignant le besoin urgent d'un investissement accru et d'une attention particulière à la recherche liée à l'IA. Les participants ont exprimé des attentes quant à l'amélioration des capacités médicales grâce à l'IA, s'alignant sur les demandes publiques plus larges en faveur des avancées dans le secteur de la santé.

Enfin, il est vital d'améliorer la formation des futurs praticiens de la santé, car presque tous les médecins interrogés ont montré un fort intérêt pour l'apprentissage des applications de l'IA. Des efforts collaboratifs entre les institutions académiques et les organisations de santé sont nécessaires pour développer des programmes d'études

pertinents et une formation pratique, renforçant ainsi le système de santé marocain et améliorant les résultats de santé. Ensemble, ces résultats soulignent l'interconnexion entre l'éducation des médecins, la sensibilisation du public et le développement des infrastructures dans l'intégration réussie de l'IA dans le paysage de la santé au Maroc.

ملخص

مقدمة: تتصدر ثورة الذكاء الاصطناعي عناوين الأخبار في جميع أنحاء العالم، حيث توفر إمكانية تحسين جودة حياتنا بشكل كبير، إلى جانب مجموعة من التصورات والخيالات المحيطة بها .وفي الوقت نفسه، تتعرض أنظمة الرعاية الصحية على مستوى العالم لضغوط متزايدة وتواجه مطالب متزايدة، بما في ذلك في المغرب .ونتيجة لذلك، يُنظر إلى الذكاء الاصطناعي كحل واعد لهذه التحديات" .ما هي توقعات "ومخاوف الأطباء وعامة السكان، لا سيما المرضى، فيما يتعلق بالذكاء الاصطناعي في الممارسة الطبية؟

الأساليب: ينقسم هذا البحث إلى مكونين رئيسيين .يركز المكون الأول على الأطباء ويستخدم تصميمًا كميًا وصفيًا مستعرضًا مستعرضًا باستخدام استبيان لجمع البيانات .أما المكون الثاني فيتناول عامة السكان)المرضى (ويستخدم أساليب نوعية من خلال مقابلات شبه منظمة .وتتضمن هذه الدراسة النوعية إجراء مقابلات فردية مع مواطنين مغاربة بالغين، باستخدام تقنيات أخذ العينات الهادفة والتوظيف باستخدام كرة الثلج .سيتم تحليل البيانات باستخدام النظرية الأساسية لاستخلاص رؤى ذات مغزى.

النتائج: ركز المكون الأول من الدراسة على الممارسين العامين في المناطق الحضرية، الذين تقل أعمارهم عن 35 عامًا في المقام الأول، بمتوسط أربع سنوات في الممارسة العملية .في حين أفاد معظمهم عن ارتياحهم لمهاراتهم في استخدام الحاسوب، واجه العديد منهم تحديات في الوصول إلى الأدوات الرقمية الأساسية، مما أعاق تبني الذكاء الاصطناعي .كان لدى جزء كبير منهم معرفة محدودة بتقنيات الذكاء الاصطناعي، مما يؤكد الحاجة إلى مبادرات تعليمية .استخدم العديد من الأطباء أدوات الذكاء الاصطناعي للمبتدئين في بعض الأحيان، مع تفاوت الثقة في قدرات الذكاء الاصطناعي على اتخاذ القرارات .كانت المخاوف بشأن مقاومة المرضى وسرية البيانات هي السائدة، لكن العديد منهم اعتقدوا أن الذكاء الاصطناعي يمكن أن يقلل من الأخطاء الطبية ويحسن الوصول إلى الرعاية في المناطق النائية.

شملت تطبيقات الذكاء الاصطناعي الرئيسية التي تم تحديدها التصوير الطبي والسجلات الصحية الإلكترونية والمراقبة عن بُعد .أعرب الأطباء عن وجهات نظر متباينة حول استبدال مهام الذكاء الاصطناعي ولكنهم شعروا بشكل عام أنه يمكن أن يخفف من عبء العمل عليهم، مما يسمح بمزيد من التركيز على رعاية المرضى .آمن نصفهم بالمسؤولية المشتركة مع مطوري الذكاء الاصطناعي ورأوا أن الذكاء الاصطناعي يمكن أن يعزز الرضا المهني .أيد أكثر من نصفهم زيادة دمج الذكاء الاصطناعي في الممارسة الطبية، حيث أعرب جميعهم تقريبًا عن اهتمامهم بمزيد من التعليم حول تطبيقات الذكاء الاصطناعي.

وبالانتقال إلى المكون الثاني، تؤكد الدراسة على الحاجة الماسة إلى زيادة الوعي بالذكاء الاصطناعي بين السكان المغاربة، لا سيما في مجال الرعاية الصحية، حيث أظهر العديد من المشاركين فهماً بسيطاً فقط .إن سد الفجوة بين الأجيال أمر ضروري، حيث أن الأفراد الأكبر سنًا غالبًا ما يعبرون عن شكوكهم تجاه الذكاء

الاصطناعي بسبب عدم إلمامهم به، في حين أن الأجيال الشابة أكثر تقبلاً بشكل عام وترى الذكاء الاصطناعي كأداة لتعزيز الكفاءة.

وعلاوة على ذلك، لا تزال هناك تحديات كبيرة في البنية التحتية في نظام الرعاية الصحية المغربي، بما في ذلك الفجوة الرقمية التي تحد من الوصول إلى التقنيات الأساسية، مما يسلط الضوء على الحاجة الملحة لزيادة الاستثمار والتركيز على البحوث المتعلقة بالذكاء الاصطناعي .أعرب المشاركون عن توقعاتهم بأن يحسن الذكاء الاصطناعي من القدرات الطبية، بما يتماشى مع المطالب العامة الأوسع نطاقاً للتقدم في مجال الرعاية الصحية.

أخيرًا، يعد تعزيز تدريب ممارسي الرعاية الصحية في المستقبل أمرًا حيويًا، حيث أظهر جميع الأطباء الذين شملهم الاستطلاع تقريبًا اهتمامًا كبيرًا بالتعرف على تطبيقات الذكاء الاصطناعي .ومن الضروري بذل جهود تعاونية بين المؤسسات الأكاديمية ومنظمات الرعاية الصحية لتطوير المناهج الدراسية ذات الصلة والتدريب العملي، مما يؤدي في نهاية المطاف إلى تعزيز نظام الرعاية الصحية في المغرب وتحسين النتائج الصحية .تؤكد هذه النتائج مجتمعةً على الترابط بين تعليم الأطباء والتوعية العامة وتطوير البنية التحتية في دمج الذكاء الاصطناعي بنجاح في مشهد الرعاية الصحية في المغرب.

APPENDICES

Appendix 1 : Physicians Survey (Questionnaire Destiné aux Médecins Marocains)

Introduction :

Cher(e) médecin,

Nous vous remercions de consacrer quelques minutes de votre temps pour participer à cette étude sur l'utilisation de l'intelligence artificielle (IA) en médecine. Cette enquête vise à recueillir votre opinion et vos perspectives sur l'intégration croissante de l'IA dans la pratique médicale. Votre contribution est essentielle pour mieux comprendre les attitudes et les besoins des professionnels de la santé face à cette évolution technologique.

L'intelligence artificielle offre un potentiel considérable pour transformer la prestation des soins de santé, en offrant des outils et des solutions innovantes pour le diagnostic, le traitement et la gestion des patients. Cependant, son adoption soulève également des questions importantes concernant son impact sur la relation médecin-patient, l'éthique médicale, et les pratiques cliniques.

Votre participation à cette enquête nous permettra d'explorer ces questions de manière approfondie et d'identifier les défis et les opportunités liés à l'utilisation de l'IA en médecine. Vos réponses contribueront à éclairer les décisions futures dans le domaine de la santé numérique et à façonner les politiques et les pratiques en matière d'IA dans le domaine médical.

Nous vous assurons que toutes vos réponses seront traitées de manière confidentielle et anonyme. Veuillez répondre honnêtement à chaque question en fonction de vos expériences personnelles et de vos opinions. Votre contribution est précieuse et nous vous en remercions à l'avance.

Merci de votre participation.

Cordialement,

Note :

Il ne s'agit pas d'un test de connaissance, mais d'une étude de croyance. Il n'y a donc pas de bonne ou mauvaise réponse. Répondre à ce questionnaire est anonyme et prend 5 minutes.

➢ **Informations générales :**

1/ Indiquez votre tranche d'âge

* Une seule réponse possible.

- Moins de 25 ans
- 25 à 34 ans
- 35 à 44 ans
- 45 à 54 ans
- 55 à 64 ans
- 65 ans et plus

2/ Indiquez votre sexe

* Une seule réponse possible.

- Homme
- Femme

3/ Indiquez votre année de thèse

4/ Indiquez votre mode d'exercice

- Médecin interne
- Médecin généraliste
- Médecin spécialiste

5/ Indiquez votre ou vos milieux d'exercice

- Rural
- Semi rural
- Urbain

6/ Nombre de consultations par jour

* Une seule réponse possible.

- Moins de 15
- 15 à 30
- 31 à 50
- 51 à 100
- Plus de 100

- **Aisance en informatique, disponibilité des outils technologiques de base et utilisation de l'IA :**

7/ Quel est votre niveau d'aisance en informatique :

Exemple des compétences requises pour chaque niveau d'aisance en informatique :

Pas du tout à l'aise :

Savoir utiliser un ordinateur (usage du clavier, de la souris, etc.)

Peu à l'aise :

Naviguer sur Internet pour consulter des informations de base.

Créer et éditer des documents dans Microsoft Word ou Excel.

À l'aise :

Résoudre des problèmes informatiques simples, comme des erreurs de logiciel ou des problèmes de connexion.

Utiliser des logiciels de visioconférence comme Zoom ou Skype.

Très à l'aise :

Programmer ou personnaliser des applications ou des logiciels.

Mettre en place des systèmes de sécurité informatique.

* Une seule réponse possible.

- Pas du tout à l'aise
- Peu à l'aise
- A l'aise
- Très à l'aise

8/Avez-vous des connaissances concernant les technologies sur lesquelles se base l'IA (ex : codage informatique, algorithmes, big data, apprentissage profond, apprentissage automatique, les réseaux de neurones, les systèmes experts) ?

* Une seule réponse possible.

- Aucune
- Limite
- Modéré
- Important

9/ Disposez-vous d'un ordinateur avec accès à Internet sur votre lieu de travail ?

* Une seule réponse possible.

- Oui, en permanence
- Oui, mais de manière limitée
- Non, mais j'ai accès à un ordinateur sans Internet
- Non, je n'ai pas d'ordinateur sur mon lieu de travail

10/Avez-vous déjà utiliser des technologies basées sur IA dans votre pratique médicale ?

- ChatGPT
- Logiciel d'aide au diagnostic (ex : Sympto-Check, Ada, etc.)
- Logiciel d'interprétation automatisée d'électrocardiogramme
- Logiciel d'aide à la prescription médicamenteuse évitant les erreurs de prescription (PocketDoc, etc.)

* Une seule réponse possible.

- Oui
- Non

Si oui, veuillez préciser le type de technologies utilisées :

11/À quelle fréquence utilisez-vous des technologies informatiques dans votre pratique médicale quotidienne ?

* Une seule réponse possible.

- Rarement
- Parfois
- Souvent
- Toujours

➢ **Niveau de confiance dans l'IA et appréhension des réactions des patients marocains :**

12/ Quel est votre niveau de confiance dans la capacité de l'IA à prendre des décisions médicales de manière autonome ?

* Une seule réponse possible.

- Pas du tout confiant
- Peu confiant
- Modérément confiant
- Très confiant

13/ Comment pensez-vous que les patients marocains réagiraient à l'utilisation de l'intelligence artificielle dans leur prise en charge médicale ?

* Une seule réponse possible.

- Sans opinion
- Reaction negative
- Reaction positive
- Reaction Neutre

- **Influence de l'IA dans la pratique médicale :**

14/ Comment pensez-vous que l'intégration de l'IA pourrait influencer la relation médecin-patient ?

- Renforcer la confiance entre le médecin et le patient en fournissant des diagnostics plus précis et des recommandations de traitement basées sur des données probantes. (+)

- Risque de déshumanisation des interactions, avec une diminution de l'aspect humain et de l'empathie dans la relation médecin-patient. (-)

* Une seule réponse possible.

- Influence positive
- Influence négative
- Pas d'influence

15/ Avez-vous des préoccupations concernant la confidentialité des données médicales lors de l'utilisation de l'IA ?

* Une seule réponse possible.

- Oui
- Non
- Sans opinion

16/ Pensez-vous que l'intégration de l'IA contribuera à la réduction de la charge de travail des médecins ?

* Une seule réponse possible.

- Oui
- Non
- Sans opinion

17/ Pensez-vous que l'intégration de l'IA augmentera ou diminuera le risque d'erreurs médicales ?

* Une seule réponse possible.

- Augmentera le risque
- Diminuera le risque
- Aucun impact sur le risque

18/ Pensez-vous que l'IA pourrait accroître l'accès à des soins de santé spécialisés dans les régions éloignées ?

* Une seule réponse possible.

- Oui
- Non
- Sans opinion

➢ **Meilleures Applications et Principaux Défis de l'IA en Pratique Médicale :**

19/ Quelles seraient, selon vous, les meilleures applications de l'intelligence artificielle dans la pratique médicale ?

* Veuillez sélectionner jusqu'à quatre réponses.

- Diagnostic des maladies
- Dépistage précoce des maladies
- Analyse d'imagerie médicale
- Assistance à la chirurgie
- Elaboration de stratégies thérapeutiques personnalisée
- Suivi et surveillance des patients à distance
- Gestion des dossiers médicaux électroniques

20/ Quels sont, selon vous, les principaux défis ou obstacles à l'adoption de l'intelligence artificielle dans la pratique médicale ?

* Veuillez sélectionner jusqu'à quatre réponses.

- Manque de confiance dans la précision des algorithmes d'IA
- Confidentialité et sécurité des données médicales
- Perte de l'aspect humain et l'empathie dans les interactions
- Préoccupations éthiques liées à l'utilisation de l'IA en médecine
- Coût élevé de mise en œuvre des technologies d'IA
- Impact potentiel sur l'emploi dans le secteur de la santé
- Manque de formation et de connaissances des médecins sur l'IA

➢ **Impact de l'IA sur la vie professionnelle des Médecins :**

21/ Craignez-vous que l'intelligence artificielle puisse remplacer les médecins dans certaines tâches ou fonctions médicales ?

* Une seule réponse possible.

- Oui, je crains qu'elle remplace plusieurs tâches médicales.
- Oui, mais seulement pour les tâches répétitives et administratives.
- Non, je pense que l'IA ne remplacera que peu de tâches médicales.
- Non, l'IA ne remplacera pas les médecins dans leurs fonctions essentielles.

22/ Comment pensez-vous que l'IA affectera la responsabilité professionnelle des médecins dans leur pratique médicale ?

* Une seule réponse possible.

- o Augmentera la responsabilité en cas d'erreurs liées à l'IA
- o Réduira la responsabilité en déléguant certaines tâches à l'IA
- o Nécessitera une responsabilité partagée entre médecins et développeurs d'IA
- o N'aura pas d'effet significatif sur la responsabilité professionnelle

23/ Pensez-vous que l'adoption croissante de l'IA dans la pratique médicale pourrait affecter votre satisfaction professionnelle en tant que médecin ?

* Une seule réponse possible.

- o Améliorerait ma satisfaction
- o Diminuerait ma satisfaction
- o Aucun impact sur ma satisfaction

➢ **Avis sur l'Intégration Accrue et la Formation en IA dans la Pratique Médicale :**

24/ Êtes-vous favorable à l'intégration accrue de l'intelligence artificielle dans la pratique médicale ?

* Une seule réponse possible.

- o Oui
- o Non
- o Sans opinion

25/ Envisagez-vous d'approfondir vos connaissances sur l'intelligence artificielle et son application en médecine à l'avenir ? (Formations, Congres…)

- o Oui, certainement
- o Non, probablement pas

➢ **Suggestions et commentaires supplémentaires :**

26/ Avez-vous des commentaires ou des suggestions concernant l'intégration de l'intelligence artificielle dans la pratique médicale ?

Appendix 2: The Institutional Review Board Approval Document

Président:
S. AIT BENALI
Vice président:
D. BOUMZEBRA
Membres :
N. ABOUSSAIR
L. ADARMOUCH
S. AIT BATAHAR
H. ASMOUKI
F. ASRI
M. CHERKAOUI
N. EL ANSARI
M.EL HATTAOUI
K. FOURAIJI
M. KHOUCHANI
N. MANSOURI
S. ZAOUI

Comité d'Éthique
Hospitalo-universitaire de Marrakech

Objet : Décision du Comité sur le protocole soumis

Titre du travail de recherche:

les Perceptions des patients Marocains concernant le développement et l'integration de l'intelligence Artificielle dans la partiaue médicale

N° 118/2024

Investigateurs principaux: Sabik Ayoub
Ait Batahar Salma

Le comité a reçu votre protocole le 29 Juillet 2024.

Le Comité a étudié vos protocoles après rectifications le 05 Septembre 2024 et les membres ont émis la délibération suivante : **Avis favorable.**

Le comité demande à l'investigateur de rapporter tout incident éventuel survenant lors du déroulement de l'étude et de l'informer sur sa clôture et ses résultats.

Date : 09/09/2024

Signature :

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قسم الطبيب

أقْسِم بِالله العَظِيم

أن أراقبَ الله في مِهْنَتِي.

وأن أصُونَ حياة الإنسان في كآفّةِ أطوَارهَا في كل الظروف والأحَوال باذلا وسْعِي في انقاذها مِن الهَلاكِ والمرَضِ والألَم والقَلَق.

وأن أحفَظَ لِلنَاسِ كرَامَتهُم، وأسْتر عَوْرَتهُم، وأكتمَ سِرَّهُمْ.

وأن أكونَ عَلى الدوَام من وسائِل رحمة الله، باذلا رعايتي الطبية للقريب والبعيد، للصالح والطالح، والصديق والعدو.

وأن أثابر على طلب العلم، وأسَخِّرَه لِنَفْعِ الإنْسَان لا لأذَاه.

وأن أُوَقّرَ مَن عَلَّمَني، وأُعَلّمَ مَن يَصْغرَني، وأكون أخا لِكُلّ زَميلٍ في المِهنَةِ الطِّبِّيَة مُتعَاونِينَ عَلى البرّ والتقوى.

وأن تكون حياتي مِصْدَاق إيمَاني في سِرّي وَعَلانيَتي، نَقِيَّة مِمّا يُشينهَا تجَاهَ الله وَرَسُولِهِ وَالمؤمِنين.

والله على ما أقول شهيد

كلية الطب والصيدلة - مراكش
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السنة 2024 الاطروحة رقم 422

تأثير الذكاء الاصطناعي على الممارسة الطبية :
آمال واهتمامات الأطباء والمرضى في السياق المغربي

الأطروحة

قدمت ونوقشت علانية يوم 2024/11/14
من طرف

السيد أيوب سابك
المزداد في 25/11/1999 بمدينة مراكش

لنيل شهادة الدكتوراه في الطب

الكلمات المفتاحية

الذكاء الاصطناعي - الممارسة الطبية - التوقعات - المخاوف - السياق المغربي

اللجنة

السيد	م .بوالروس أستاذ في طب الأطفال	الرئيسة
السيدة	س .أيت بطاهر أستاذة في الامراض التنفسية	المشرفة
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