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Investigating students' perception of artificial intelligence in the medical field.

THESIS

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BY

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KEY WORDS

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بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

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

صَدَقَ ٱللَّهُ ٱلْعَظِيمُ

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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Liste arrêtée le 24/07/2024

DEDICATIONS

Tout d'abord à ALLAH

Le tout puissant et miséricordieux, qui m'a donné la force et la patience d'accomplir ce modeste travail.

Qui m'a inspirée et guidée dans le bon chemin, Je lui dois ce que je suis devenue.

Louanges et remerciements pour sa clémence et sa miséricorde.

الْحَمْدُ لِلَّهِ الَّذِي بِنِعْمَتِهِ تَتِمُّ الصَّالِحَاتُ

À mes chers parents :

Ce travail est autant le vôtre que le mien. Puisse cette thèse symboliser le fruit de vos longues années de sacrifices consentis pour mon éducation et mes études.

À ma précieuse maman HADROUNE Malika :

Aucune parole ne pourrait exprimer à quel point je suis chanceuse de t'avoir. Tu as été un pilier pour moi dans chaque épreuve. Tu m'as appris à endurer et à poursuivre mes objectifs, toujours là, me soutenant à chaque étape du chemin. Savoir que je pouvais toujours compter sur ton soutien m'a toujours donné un profond sentiment de sécurité. J'aspire à être ne serait-ce qu'à moitié aussi forte et chaleureuse que toi. Je ne saurais exprimer à quel point je suis profondément reconnaissante de t'avoir à mes côtés.

À mon cher père AERGOUB Mimoune :

Tu m'as appris à être bienveillante et attentive aux autres, à avancer dans la vie avec un esprit altruiste et de bonnes intentions. Ton âme est le reflet de tes valeurs. J'ai toujours admiré ta capacité à voir le meilleur en chacun. Chaque jour, je trouve mon inspiration en toi et je m'efforce d'être la meilleure version de moi-même. J'aspire à porter notre nom de famille d'une manière digne de tes valeurs et de ta morale.

To my lovely Sisters: Aya et Salma

Surprisingly, I wouldn't trade you for the world.

To AERGOUB Aya:

My lifelong companion, through everyday life, birthdays, and chaotic vacations. Through our tantrums, frustrations, ramblings, burrowed clothes and a thousand and one failed pictures.

I've been a witness to your iconic fake cry as a child and every important milestone since. Seeing you blossom into such a warm and remarkable person has been a source of tremendous pride. Although, it has been a little embarrassing to watch you grow taller than me, I love you regardless.

To AERGOUB Salma:

Our little hot headed one. I often joke about your obstinate personality, but I see your confidence and your curious soul leading you to the achievements of all your hopes and dreams. Every moment of your growth fills my heart with pride. I know you aspire to achieve wonderful things in life, so I hope your journey is filled with all the beauty, love, and the contentment you truly deserve.

To my dear brother Salaheddine:
Despite our differences, I know you walk through life with good intentions. I hope you receive all the goodness this world has to offer, and may your deepest wishes be fulfilled.

À ma bien-aimée grand-mère maternelle :
Ma motivation tout au long de ce parcours a été le sentiment de fierté que vous m'avez inspiré. En m'appelant "Tbiba" dès ma première année de médecine, vous avez fait naître en moi le désir de donner le meilleur de moi-même dans tout ce que je fais, et envers mes patients, en eux, j'ai toujours vu votre visage. J'espère que vous êtes aussi fière que je l'ai toujours voulu.

À la mémoire de mon grand-père maternel :
Bien que tout ce que je sache de vous soit l'honorable souvenir que vous avez laissé de votre vie, à travers ma mère et ma grand-mère, je vous dédie ce travail. Que votre âme repose en paix.

À la mémoire de mon grand-père paternel :

Je me souviens qu'enfant, j'adorais nos visites à Meknès, la vieille maison et les réunions de famille. Bien que je ne garde en mémoire que des fragments de nos moments passés ensemble Ba, je reconnais toujours le fait que tu es la personne la plus gentille que j'ai jamais eu le plaisir de connaître. Je vois encore les reflets de tes meilleures qualités en mon père et j'espère que les personnes que je connais et celles que je n'ai pas encore rencontrées pourront témoigner de la chaleur de vos deux âmes à travers tout ce que je fais. Que ton âme repose en paix.

À la mémoire de ma grand-mère paternelle :

À ma très chère MI, j'avoue qu'enfant, j'adorais ta générosité et tes petits cadeaux à chaque visite. Je garde encore en mémoire mon bonheur chaque fois que tu reconnaissais mon visage même si tu ne te souvenais pas grand-chose à ce moment-là. Je n'ai pas pu te dire au revoir une dernière fois, mais sache que je ferai toujours de mon mieux pour honorer ta mémoire. Que ton âme repose en paix.

À TOUTE LA FAMILLE AERGOUB
À TOUTE LA FAMILLE HADROUNE

À ma très chère famille,

Vous êtes et serez toujours pour moi une source d'inspiration sans retour. Votre tendresse et l'accueil que vous avez toujours su me faire comme votre propre fille m'ont toujours touchée au-delà des mots. Vous avez su encourager mes élans, me soutenir et me combler d'amour. J'espère, de tout cœur, vous avoir rendus fiers, comme chaque jour vous l'êtes pour moi.

A TOUS MES COUSINS ET COUSINES

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To the group: *You have been the best of sisters to me and I'm so lucky to have met you.*

To ABOUSSAD Chaymae

I guess our friendship just happened naturally. We lived through the craziest library studying sessions, the cringiest jokes, lengthy discussions around the silliest of characters and most importantly your singing voice records. We've gone from suturing torn hospital beds to suturing real wounds. Throughout all these years, you have been the number one K-Drama partner and most importantly the best of confidants. Medical studies have been a pleasure with you.

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Khadija El mouhammadi: *Our friendship somehow made it through the work of time and the "long" distance. We have always been in sync that even when we don't see each other for long, our meetings and gossip always hit the same. Watching us grow together has been such a joy.*

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To those who have marked my journey, though not explicitly named, were invaluable to this work: Thank you for everything.

And finally, to myself: *"What is done with love is done well"-Vincent Van Gogh*

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Vice Dean of research and cooperation, head of the clinical research center and Professor of clinical epidemiology.

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Head manager of adult emergency department at Ibn Tofail hospital and Professor of anesthesia and resuscitation

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To our esteemed jury member Professor NEJMI Hicham:

Head of the emergency department at Mohamed VI University Hospital and Professor of anesthesia and resuscitation:

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To our esteemed jury member Professor RAIS Hanane

Head of the Department of Pathology at Mohamed VI University hospital and Professor of Pathology:

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Head of the Department of Radiology at Mohamed VI University hospital and Professor of Radiology

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ABREVIATIONS

LIST OF ABBREVIATIONS

AI	: Artificial intelligence
AIM	: Artificial intelligence in medicine
EHRs	: Electronic health records
DeepQA	: Deep learning-based question answering (QA) system.
DL	: Deep learning
FMPA	: Faculty of Medicine and Pharmacy of Agadir
FMPC	: Faculty of Medicine and Pharmacy of Casablanca
FMPE	: Faculty of Medicine and Pharmacy of Errachidia
FMPF	: Faculty of Medicine and Pharmacy of Fez
FMPL	: Faculty of Medicine and Pharmacy of Laayoune
FMPM	: Faculty of Medicine and Pharmacy of Marrakech
FMPO	: Faculty of Medicine and Pharmacy of Oujda
FMPR:	: Faculty of Medicine and Pharmacy of Rabat
FMPT	: Faculty of Medicine and Pharmacy of Tangier
HIT	: Healthcare information technology
IT	: Information technology
ML	: Machine learning

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OUTLINE

INTRODUCTION

The official birth of the term artificial intelligence was first traced to the scientist John McCarthy in 1956. AI, while not precisely defined, refers to the technology that allows machines and computers to mimic or stimulate human behavior, such as the ability to be autonomous, solve problems, make decisions, learn, and be creative. It marks what many consider a component of the fourth industrial revolution, following the invention of steam engines, electricity, and digital technology [1–3].

Currently, the field of AI has witnessed a resurgence, managing to propagate to several major sectors, including health care. The AI market is projected to reach $127 billion in 2025, with the medical industry accounting for 20% [4]. AI in medicine (AIM) has recently shown growth in many medical specialties, including biology, pathology, and radiology [5,6]. It has been promising several breakthroughs in medical care, such as enhancing efficiency and diagnosis, advanced data analysis, imagery interpretation, personalized treatments and health monitoring. Additionally, it's envisioned that AI will optimize hospital operations, drug discovery, and predictive analysis [7].

AI advancement in medicine raises both optimism and concern among healthcare workers and students alike. While its integration offers new opportunities, it also introduces ethical, legal, and social challenges, as well as questions around curriculum tailoring to include AI education.

Medical students are regarded as future caregivers and one of the determinants of the effectiveness of integrating AI technology into the healthcare system. Hence why it is important to note the way they perceive AI to understand the potential and limitations of its adoption in medical care. Furthermore, considering AI developments, its integration into the medical curriculum has become an important topic to guide medical schools in reforming education to include different facets of AI. The World Medical Association recommends a revision of medical curricula and educational opportunities for all healthcare participants, including students [8,9].

Our study's main objective is to assess the perception of medical students in Morocco regarding the role of artificial intelligence in the medical field. It aims to explore students' level of

AI knowledge and its applications in healthcare. Additionally, it intends to evaluate their attitudes toward AI's potential impact on clinical roles, job allocation, ethical and legal challenges. Moreover, this study aims to investigate students' perception on incorporating AI training into the medical curriculum to better prepare them for future healthcare challenges, ultimately raising AI literacy among future healthcare providers.

PARTICIPANTS AND METHODS

I. Study design:

Our work is an observational cross-sectional study conducted over 4 months, between June and September of 2024. We explored students' perception of artificial intelligence and its integration in the medical field with its various aspects. For that purpose, students were questioned through a self-administered survey that we developed for this study and that we made available online via google forms.

II. Study population:

Our target population was first to final year medical students, and those with an awaiting thesis status, from the following Moroccan public medical schools:

- Faculty of Medicine and Pharmacy of Marrakech (FMPM)
- Faculty of Medicine and Pharmacy of Agadir (FMPA)
- Faculty of Medicine and Pharmacy of Rabat (FMPR)
- Faculty of Medicine and Pharmacy of Tangier (FMPT)
- Faculty of Medicine and Pharmacy of Casablanca (FMPC)
- Faculty of Medicine and Pharmacy of Fez (FMPF)
- Faculty of Medicine and Pharmacy of Oujda (FMPO).
- Faculty of Medicine and Pharmacy of Laayoune (FMPL).
- Faculty of Medicine and Pharmacy of Errachidia (FMPE).

❖ Inclusion criteria:

- All students from the first to final year of medicine including students with a thesis awaiting status and medical interns.
- Students currently enrolled in medical public schools all over Morocco.

❖ Exclusion criteria:

- Individuals unable to provide informed consent.
- Unwillingness to fill out the questionnaire.
- Incomplete or inappropriately filled questionnaires.

III. Sampling method:

We recruited students from the faculties of medicine and pharmacy using a voluntary response sampling method given the online nature of the study.

IV. Sample size:

A total of 310 students completed the survey during the set period.

V. Survey design:

We designed a self-administered survey based on a literature review of relevant studies accessed via PubMed and Google Scholar. The final questionnaire consisted of 46 questions divided into six sections [10-12].

Section 1: Students' profile: 4 Questions:

This section captured demographic information, including age, gender, faculty, and level of study.

Section 2: General awareness: 4 Questions:

This section included four questions aimed to assess medical students' general level of knowledge on artificial intelligence.

- The first question intended to evaluate students' agreement on the definition of AI with a binary yes or no answer.
- The second question was a follow up open question for students who disagreed with the proposed definition in which they provided their own.
- The third and fourth questions used a 5-point Likert scale to rate students' knowledge on AI and their level of familiarity with AI applications in healthcare.

Section 3: Students' perception regarding the application of AI in the medical field: 16 questions:

This section included sixteen questions aimed to evaluate the perception of students regarding AI in the medical field.

- The first question was a closed-ended question about the willingness to use AI as a diagnostic tool.

- The second question was multiple choice to assess the tasks that students believe can be delegated to AI.
- The third question was multiple choices to assess students' perceptions of the possible implementation plans.
- Questions four to sixteen were a 5-point Likert scale questions with different items assessing potential AI influence in medicine, its practice, medical decisions, prescription, access to information as well as its potential effect on medical errors rate, on patients care and trust, the gestion of time, resources and the inadequacy between medical care demand and healthcare workers.

Section 4: Students' perception regarding the influence of AI on jobs and specialty choices: 6 questions:

- The first question was a closed ended one around the possibility of AI replacing clinical practitioners.
- The second question was a follow up multiple choice question for those who marked an agreement to evaluate their opinion regarding the specialties they believed to be replaceable by AI.
- Question three to six were a 5-point Likert scale questions concerning the influence AI will have on medical jobs and specialty choices, and whether AI can replace some specialties in the future.

Section 5: Student's perception regarding ethical and legal challenges of AI: 10 questions:

This section concerned the ethical legal parts of AI implementation in healthcare.

- Question one to seven were a 5-point Likert scale questions concerning the safety of AI, the effect of AI on the human aspect of medical practice as well as the doctor/patient relationship, the possibility of implementing AI in our context and the ethical part of it.
- Questions eight and nine were multiple-choice concerning the liability in case of AI mistakes and the challenges of AI implementation.

- The 10th question was an open question regarding suggested legal or ethical challenges that should be taken into consideration before the implementation of AI.

Section 6: Students' perception regarding AI teaching in the medical curriculum: 6 questions:

- The first question was a 5-point Likert scale question regarding the level of agreement about integrating AI education into the curriculum.
- The second question was a follow up open question for students who marked disagreement regarding the integration of AI education in the curriculum.
- The third question was a neutral/agreement based multiple-choice question regarding the right time to include AI education in the medical curriculum.
- The fourth question was a neutral/agreement based multiple-choice question regarding the forms in which AI education should be included.
- The fifth was an open question concerning suggestions about AI-related topics that should be taught in medical schools.
- The sixth question was an open question regarding the use of chat-bots and LLMs in medical education.

VI. Pilot Testing:

The survey was pilot tested with 10 Moroccan medical students from different study levels to evaluate the clarity of the different items.

VII. Survey distribution:

We created an online survey using the platform Google forms. It was designed originally in English then translated to French. Both versions were distributed online through medical student groups on social media platforms to reach our large target study.

VIII. Data analysis:

Descriptive statistics (frequencies and percentages) and bivariate analysis were calculated using SPSS software (version 23), and the results were visualized using Microsoft Excel 2019.

IX. Ethical approval and consent:

The participants' consent was obtained on the first section of the survey.

The significance and the objective of the study were clearly stated and explained as well as the reassurance concerning the confidentiality of data collection.

RESULTS

I. Students profile:

The total number of participants in our study was 310 (N=310).

1. Age:

The ages 24 and 25 were the most common in our sample, at a rate of 14.2% each (n=44). The median age was 22 in an age range from 17 to 29. The average was 22.37 with a standard deviation of 2.506.

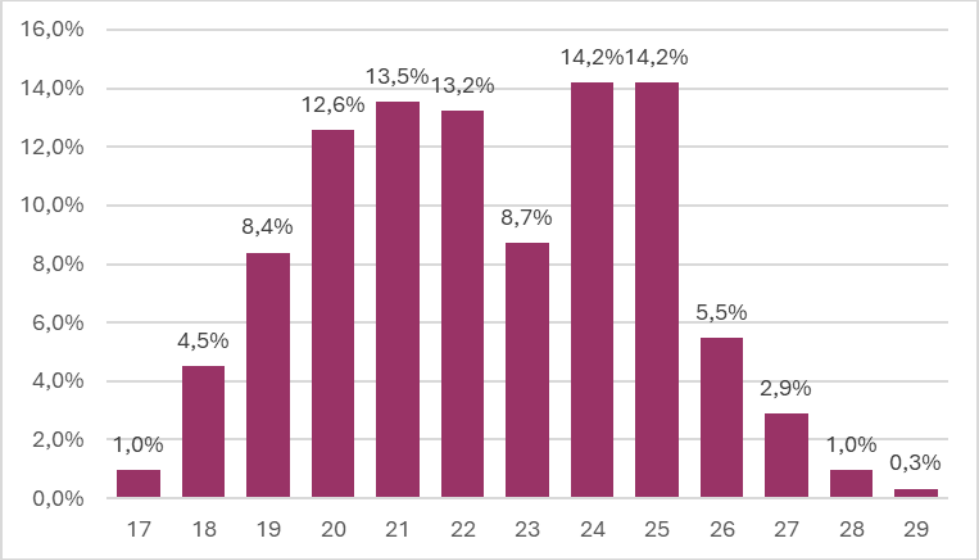

Figure 1: Distribution of students by age.

2. Gender:

Our sample consisted of 60.6% women (n=188) and 39.4% men (n=122), which represents a sex ratio of 0.65.

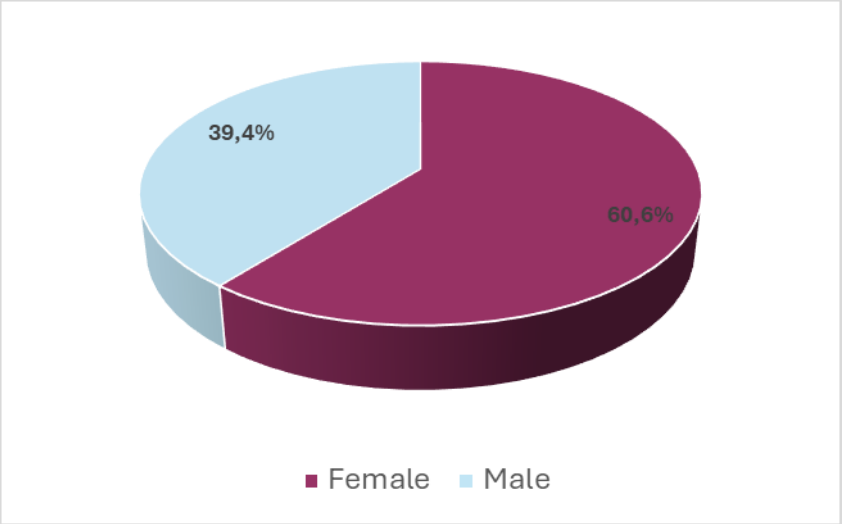

Figure 2: Distribution of students by gender.

3. Medical faculty:

The surveyed students were from nine public medical schools. Most participants were from the FMPM representing 38.4% (n=119) of the total respondents. The next largest group was from the FMPC, at 14.5% (n=45). The FMPT and FMPR had a rate of 11.9% (n=37) and 11.6% (n=36), respectively. We received 7.7% (n=24) of responses from the FMPF, 6.5% (n=20) from the FMPA and 5.8% (n=18) from the FMPO. The FMPL had a rate of 3.2% (n=10). There was one response from FMPE (0.3%).

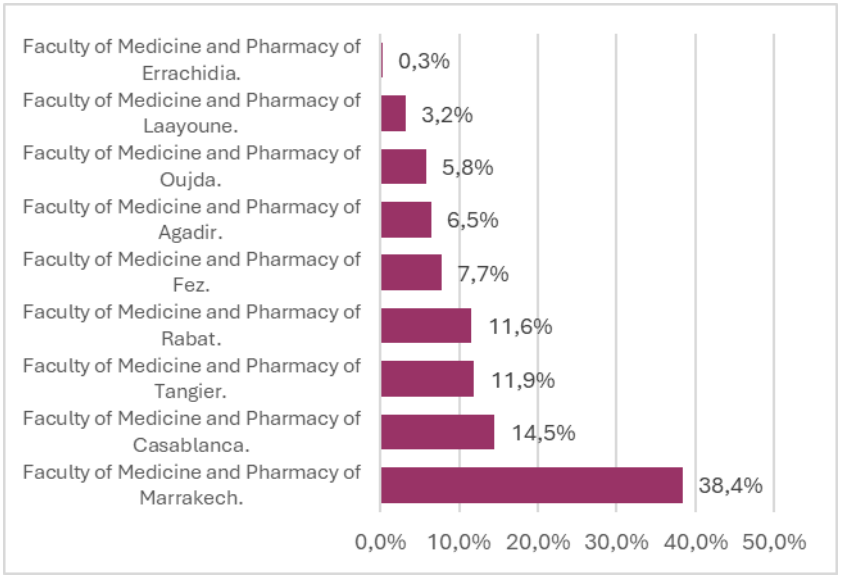

Figure 3: Distribution of students by their medical faculty.

4. Level of studies:

The distribution of students according to their level of study showed the highest participation rate from 7th year medical students, accounting for 20% (n=62). 4th year medical students were next at 14.8% (n=46), closely followed by 2nd year medical students with 12.9% (n=40). 3rd year medical students represented 12.3% of the total respondents (n=38), 10.6% (n= 33) for both 1st year medical students and respondents with a thesis awaiting status. Fifth year medical students represented 10% (n=31), and finally 8.7% (n=27) for 6th year medical students.

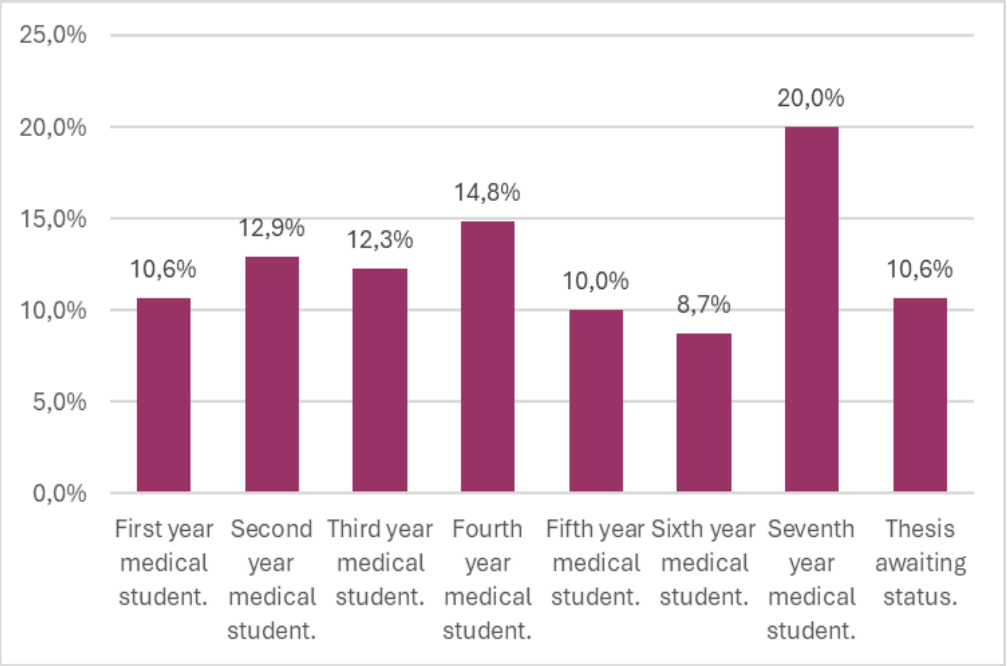

Figure 4: Distribution of students by their level of study.

Table 1: Students' profile.

Characteristics	Number	Percentage
N=310		
Gender		
– Male	– 188	– 60.6%
– Female	– 122	– 39.4%
Age		
– 17 years old	– 3	– 1%
– 18 years old	– 14	– 4.5%
– 19 years old	– 26	– 8.4%
– 20 years old	– 39	– 12.6%
– 21 years old	– 42	– 13.5%
– 22 years old	– 41	– 13.2%
– 23 years old	– 27	– 8.7%
– 24 years old	– 44	– 14.2%
– 25 years old	– 44	– 14.2%
– 26 years old	– 17	– 5.5%
– 27 years old	– 9	– 2.9%
– 28 years old	– 3	– 1%
– 29 years old	– 1	– 0.3%
Medical faculty:		
– FMPM	– 119	– 38.4%
– FMPC	– 45	– 14.5%
– FMPT	– 37	– 11.9%
– FMPR	– 36	– 11.6%
– FMPF	– 24	– 7.7%
– FMPA	– 20	– 6.5%
– FMPO	– 18	– 5.8%
– FMPL	– 10	– 3.2%
– FMPE	– 1	– 0.3%
Level of studies:		
– 1st year medical student	– 33	– 10.6%
– 2nd year medical student	– 40	– 12.9%
– 3rd year medical student	– 38	– 12.3%
– 4th year medical student	– 46	– 14.8%
– 5th year medical student	– 31	– 10%
– 6th year medical student	– 27	– 8.7%
– 7th year medical student	– 62	– 20%
– Thesis awaiting status	– 33	– 10.6%

II. General awareness of AI among students:

1. Agreement with AI definition:

Amongst the 310 respondents, 83.9% (n=260) agreed with the given definition, while the remaining 16.1% (n=50) disagreed.

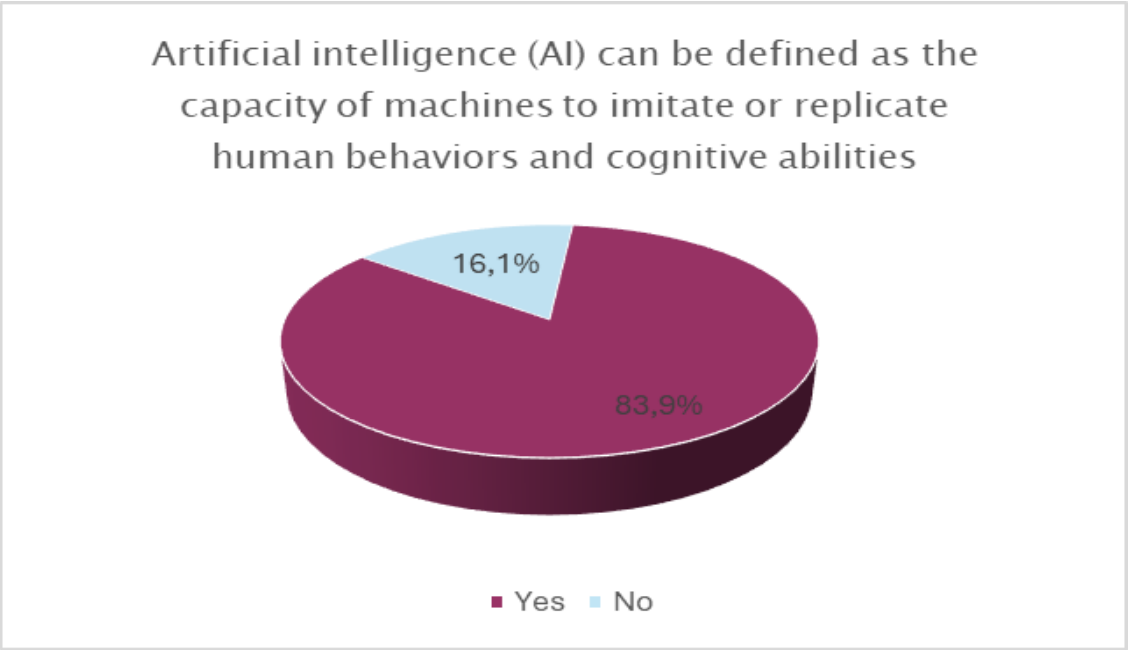

Figure 5: Students' agreement with the definition of AI.

2. Level of AI knowledge: Respondents' self-rating on a 5-point Likert scale:

According to the results, 43.9% (n=136) of participants rated their knowledge as basic, followed by 30.3% (n=94) who rated it as minimal. 12.3% (38) of our students considered their knowledge to be adequate, whereas 11.3% (n=35) of our respondents rated themselves as not knowledgeable at all. Only 2.3% (n=7) rated their level of knowledge as extensive.

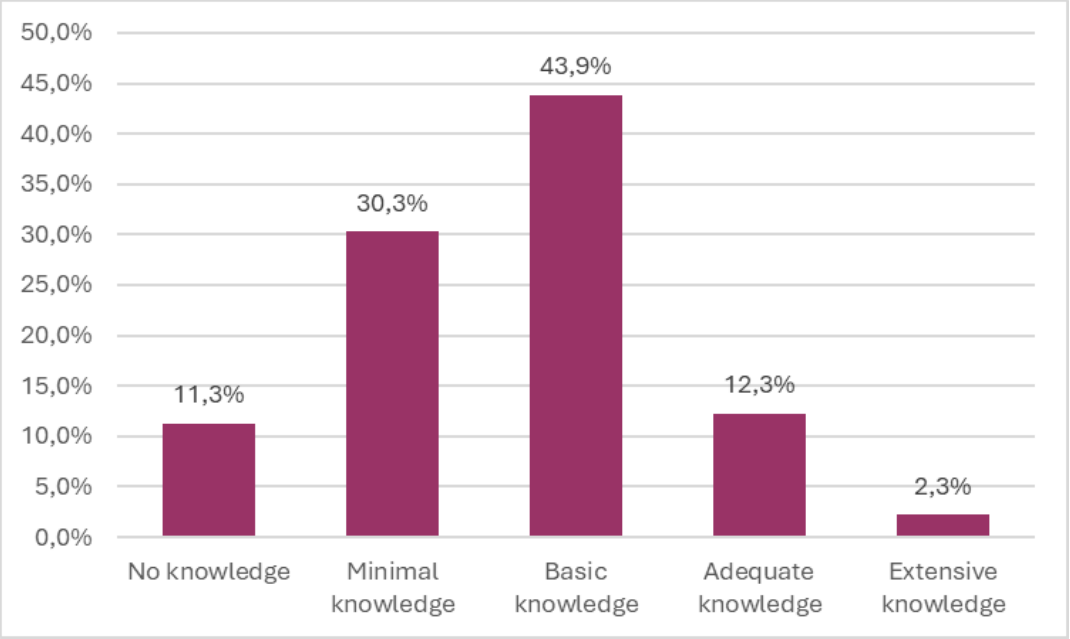

Figure 6: Students' level of AI knowledge.

3. Level of familiarity with AI applications in healthcare: Respondents' self-rating on a 5-point Likert scale:

Based on the data, 43.4% (n=135) of the respondents rated their level of familiarity with AI applications in healthcare as slight, while 21.5% (n=65) considered it average. Additionally, 19.5% (n=62) of students reported being not familiar at all and 13.6% (n=42) described themselves as moderately familiar. Only 2% (n=6) rated their level of familiarity as extensive.

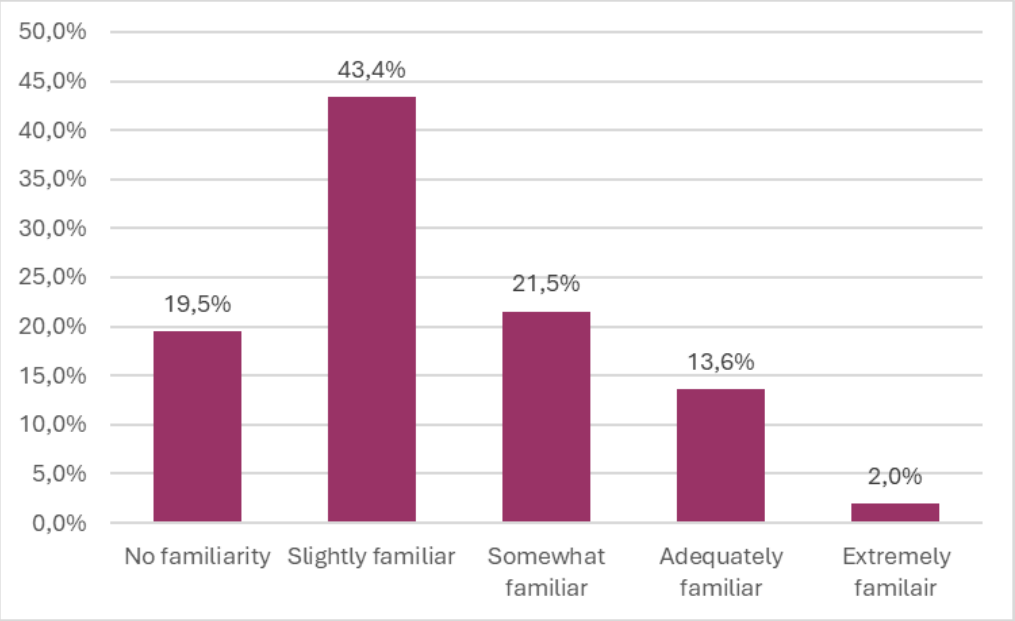

Figure 7: Level of familiarity with AI applications in healthcare.

Table 2: Summary of students' general awareness.

Characteristics	Number	Percentage
N=310		
Agreement with AI Definition		
– Yes	260	83.9%
– No	50	16.1%
Level of AI Knowledge:		
– No knowledge	35	11.3%
– Minimal knowledge	94	30.3%
– Basic knowledge	136	43.9%
– Adequate knowledge	38	12.3%
– Extensive Knowledge	7	2.3%
Level of AI familiarity in healthcare		
– Not familiar at all	62	19.5%
– Slightly familiar	135	43.4%
– Somewhat familiar	65	21.5%
– Moderately familiar	42	13.6%
– Extremely familiar	6	2%

III. The application of artificial intelligence in the medical field:

1. Respondents' openness to using AI diagnostic tools:

From the data collected, we found that 45.2% (n=140) of the students were open to using AI diagnostic tools. 43.2% (n=134) were uncertain. Only 11.6% (n=36) of the respondents were opposed to it.

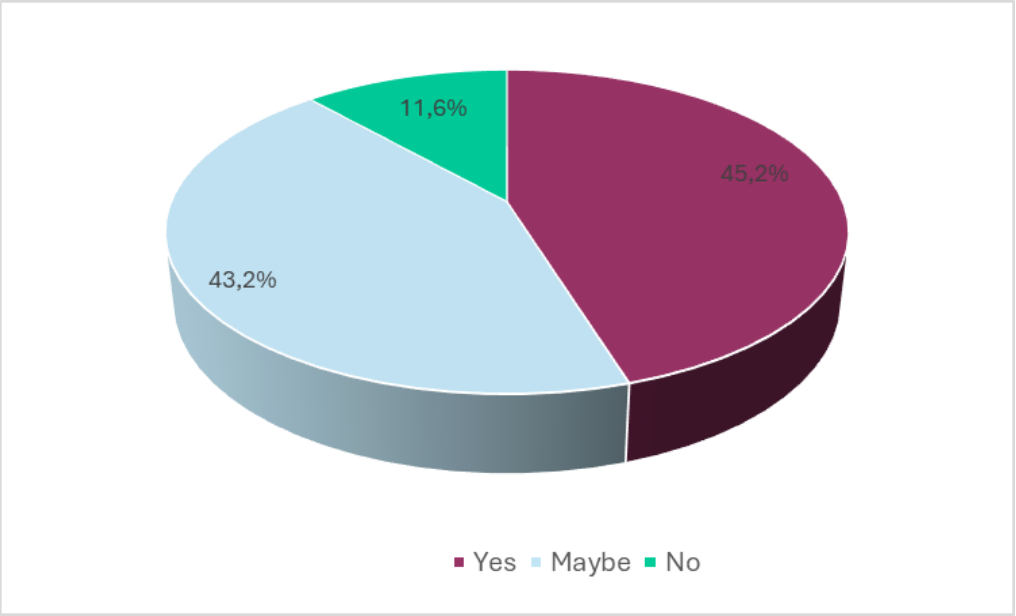

Figure 8: Openness to using AI diagnostic tools.

2. Potential delegated tasks: A multiple-choice question:

Students were allowed to select multiple answers to this question. 87.1% of our respondents were in favor of delegating health files recording to AI (n=270), 63.9% for history taking (n=198), closely followed by patient monitoring for 61.3% (n=190). 20% (n=62) of our students felt that they could delegate medical prescription to AI, while 12.9% (n=40) were in favor of delegating diagnosis and medical decisions. Only 4.5% (n=14) of the total respondents felt that no task should be delegated to AI.

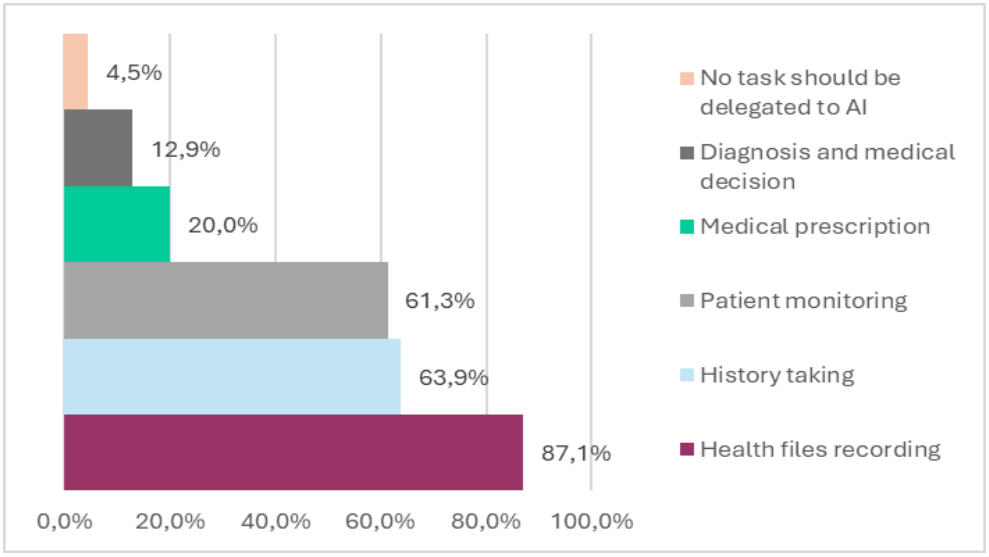

Figure 9: AI potential delegated tasks.

3. Implementation plan regarding the use of AI:

A total of 54.8% (n=170) of the answers were in favor of AI assisting in the decision making and health record filing while the final decision is for the clinician to make. 42.3% (n=131) of the total answers were in favor of AI assisting in the decision making while the final decision and health file recording is for the clinician to do. 1.6% (n=5) of the total answers supported the idea that the full process should be automated. Only 1.3% (4) of the respondents refused AI implementation.

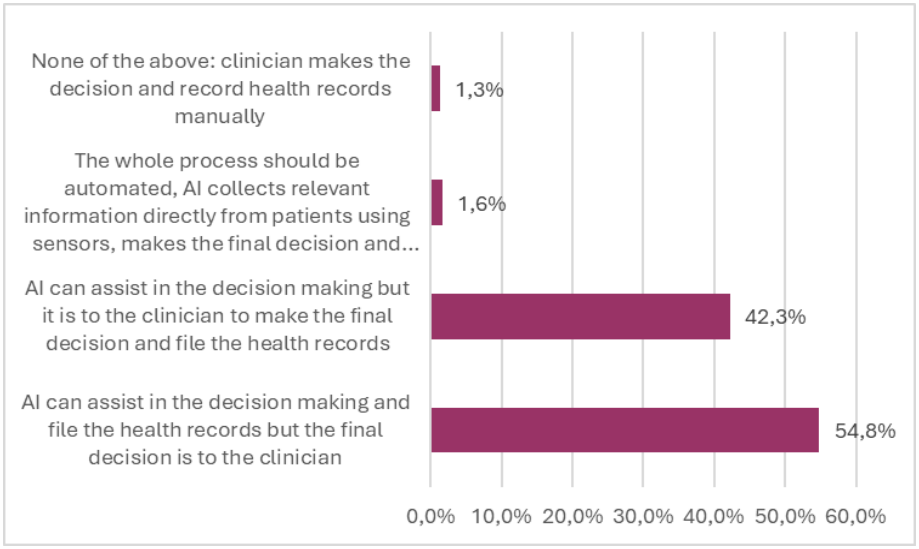

Figure 10: Implementation plan regarding the use of AI.

4. Rating of potential AI applications and influence on healthcare: Likert scale:

Across all statements, most respondents tend to agree or strongly agree. We remarqued notable peaks in agreement for these statements: AI has the potential to enhance the medical profession in general (84% in favor; 45% agree 39% strongly), AI tools and medical chatbots can make medical knowledge and information access easier for clinicians (91% in favor: 48% agreed, 43% strongly agreed), the use of AI will help in resources and time saving (88% in favor: 51 % agreed 37% strongly agreed) and the application of AI in administrative tasks will reduce healthcare professionals' workload (89% in favor: 43% agreed 46% strongly agreed).

Neutral responses also have a significant presence, especially in these following statements: The use of AI will improve patients trust in medical decisions (39% neither agreed nor disagreed), AI can exceed human achievement in many medical areas (29% neither agreed nor disagreed) and level of trust in the guidelines established by AI through learning from medical datasets (40% neither agreed nor disagreed). Disagreement' rate is generally lower, with strong disagreement consistently being the least chosen option across all the statements.

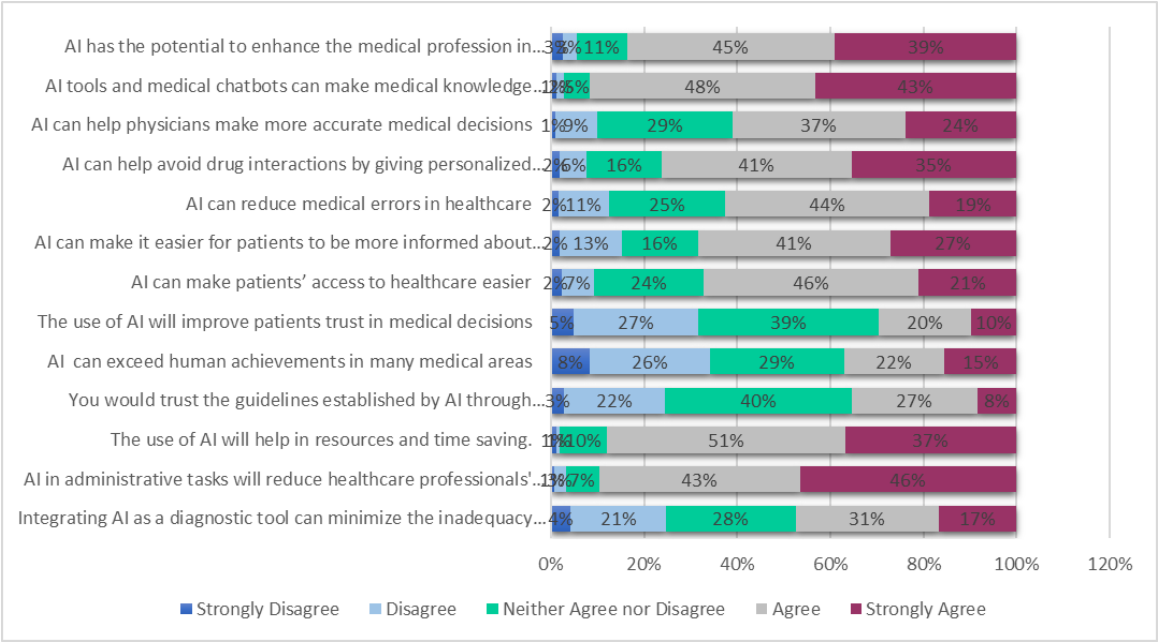

Figure 11: Rating of potential AI applications and influence in healthcare.

Table 3: Rating of potential AI applications and influence in healthcare.

	Strongly disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
AI has the potential to enhance the medical profession in general	3% (8)	3% (9)	11% (34)	45% (138)	39% (121)
AI tools and medical chatbots can make medical knowledge and information access easier for clinicians	1% (4)	2% (5)	5% (17)	48% (150)	43% (134)
AI can help physicians make more accurate medical decisions	1% (3)	9% (28)	29% (90)	37% (115)	24% (74)
AI can help avoid drug interactions by giving personalized treatments	2% (6)	6% (18)	16% (50)	41% (126)	35% (110)
AI can reduce medical errors in healthcare	2% (5)	11% (34)	25% (77)	44% (136)	19% (58)
AI can make it easier for patients to be more informed about their health	2% (6)	13% (41)	16% (51)	41% (128)	27% (84)
AI can make patients' access to healthcare easier	2% (7)	7% (22)	24% (73)	46% (143)	21% (65)
The use of AI will improve patients trust in medical decisions	5% (15)	27% (83)	39% (120)	20% (62)	10% (30)
AI can exceed human achievements in many medical areas	8% (26)	26% (80)	29% (89)	22% (67)	15% (48)
You would trust the guidelines established by AI through learning from medical datasets	3% (9)	22% (67)	40% (124)	27% (84)	8% (26)
The use of AI will help in resources and time saving	1% (4)	1% (2)	10% (31)	51% (159)	37% (114)
AI in administrative tasks will reduce healthcare professionals' workloads	1% (2)	3% (8)	7% (22)	43% (134)	46% (144)
Integrating AI as a diagnostic tool can minimize the inadequacy between the demand in medical care and the disproportionate number of clinicians	4% (13)	21% (64)	28% (86)	31% (95)	17% (52)

IV. The influence of AI on job opportunities and the choice of specialty in the medical field:

1. Future potential of AI in replacing clinical practitioners: Participants' beliefs:

Most students (83.5% n= 259) disagreed with the fact that AI can potentially replace clinical practitioners. 15.5% of the students (n=48) agreed with the statement. Only 1% (n=3) of the students expressed uncertainty.

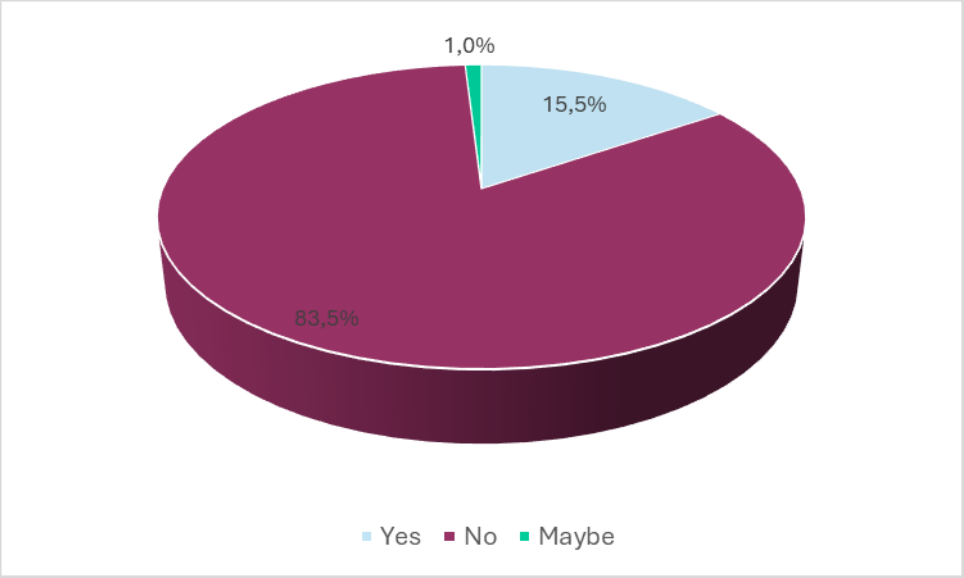

Figure 12: Level of agreement with AI's potentially replacing clinical practitioners.

2. Specialties perceived as replaceable by AI: Neutral/Agreement-based responses:

After assessing students' views on AI's potential to replace clinical practitioners, a follow up question was given to the students who answered "yes" or "maybe'' to assess which specialties they perceived as replaceable in the future. The question was multiple-choice. 66.7% of the total of these respondents indicated biology as a potentially replaceable specialty, followed by medical non-interventional specialties with 45.1%. 15.7% of our respondents felt that AI is capable of replacing all specialties. 9.8% for medical interventional specialties. And finally, only 3.9% for surgical specialties.

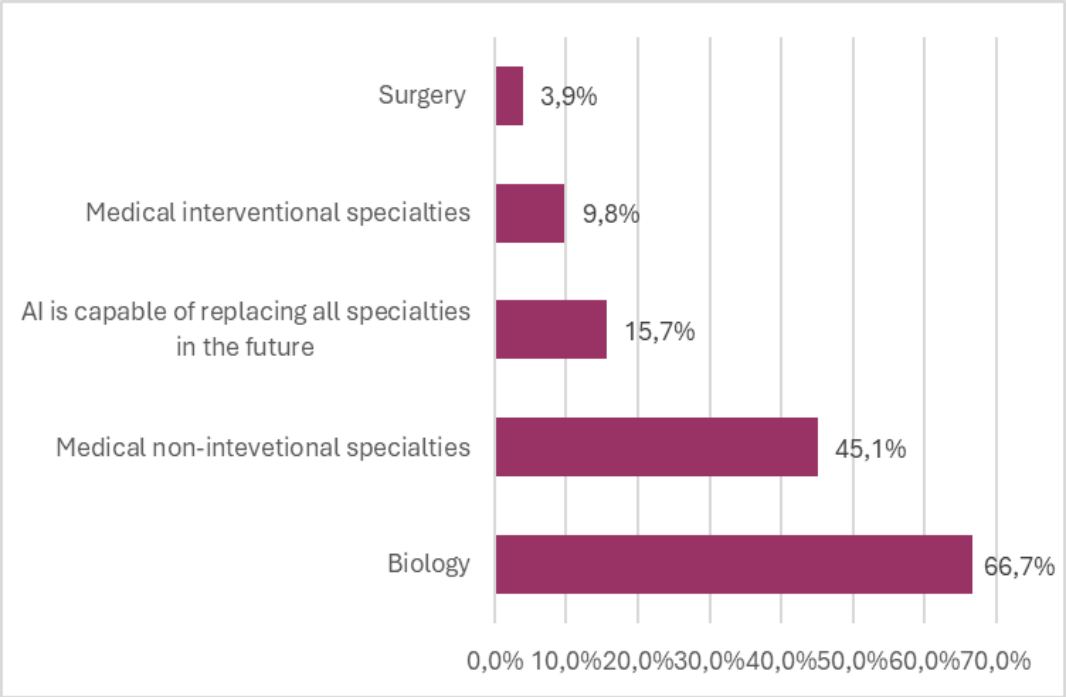

Figure 13: Specialties perceived as replaceable by AI.

3. Rating of potential AI influence on medical jobs and specialty choices:

Responses were evenly distributed with significant bunching in the neutral replies to the two statements: AI will negatively influence healthcare job prospects in the future and the use of AI in healthcare means the end to some clinical professions. Our findings showed that 58% supported that AI in healthcare would affect jobs differently by specialty. 59% supported that the choice of specialty in the future will be influenced by the number of fields that implement/use AI.

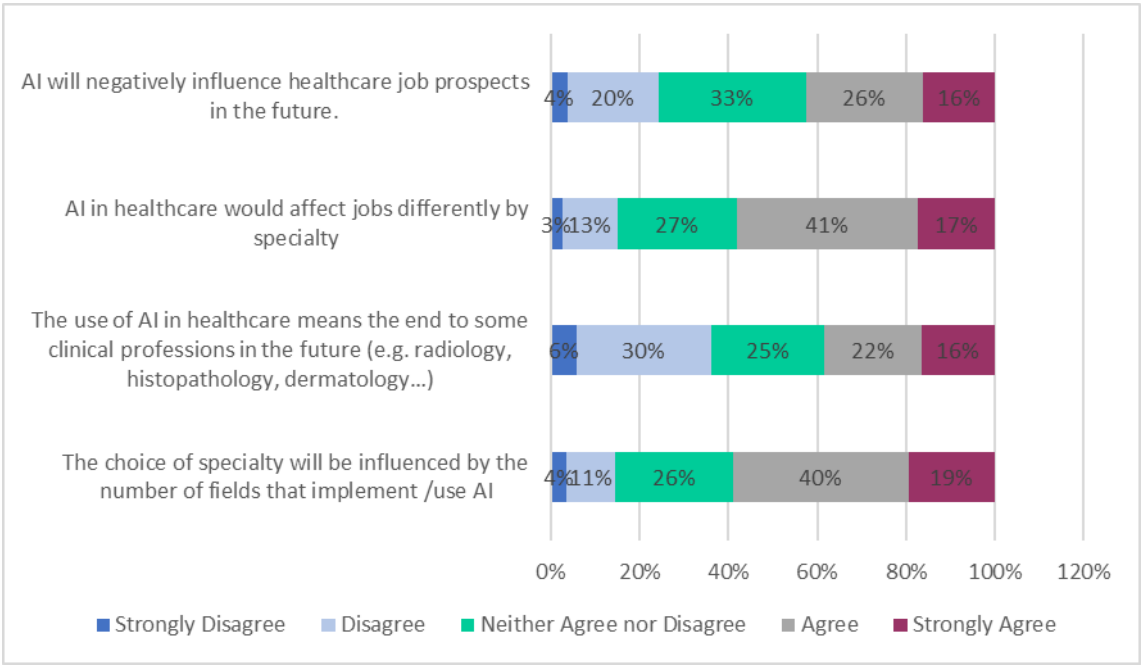

Figure 14: Rating of potential AI influence on medical jobs and specialty choices.

Table 4: Rating of potential AI influence on medical jobs and specialty choices.

	Strongly disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
AI will negatively influence the job prospects in the future	4% (12)	20% (63)	33% (103)	26% (82)	16% (50)
AI in healthcare would affect jobs differently by specialty	3% (8)	13% (39)	27% (83)	41% (126)	17% (54)
The use of AI in healthcare means the end to some clinical specialties in the future (e.g. radiology, histopathology dermatology...)	6% (18)	30% (94)	25% (79)	22% (68)	16% (51)
The choice of specialty will be influenced by the numbers of fields that implement/ use AI	4% (11)	11% (34)	26% (82)	40% (123)	19% (60)

V. The ethical implications and challenges of AI:

1. Rating of potential AI ethical implications and challenges: Likert Scale:

Most respondents tend to agree with several statements. These include AI integration in healthcare compromises the human aspect of medical practice (63% in favor:39% agreed, 24% strongly agreed) and the clinician-patient relationship (67% in favor: 40% agreed, 27% strongly agreed). Also, 82% agreed that the integration of AI in healthcare would present new ethical considerations.

Neutral responses also hold a significant portion. 32% neither agreed nor disagreed that AI in healthcare compromises its safety. Additionally, 37% neither agreed nor disagreed that AI applications respect the ethics of medical practice. Disagreements were less frequent, but still present, with up to 39% regarding the possibility of implementing AI in healthcare in our social context (31% disagreed and 8 % strongly disagreed).

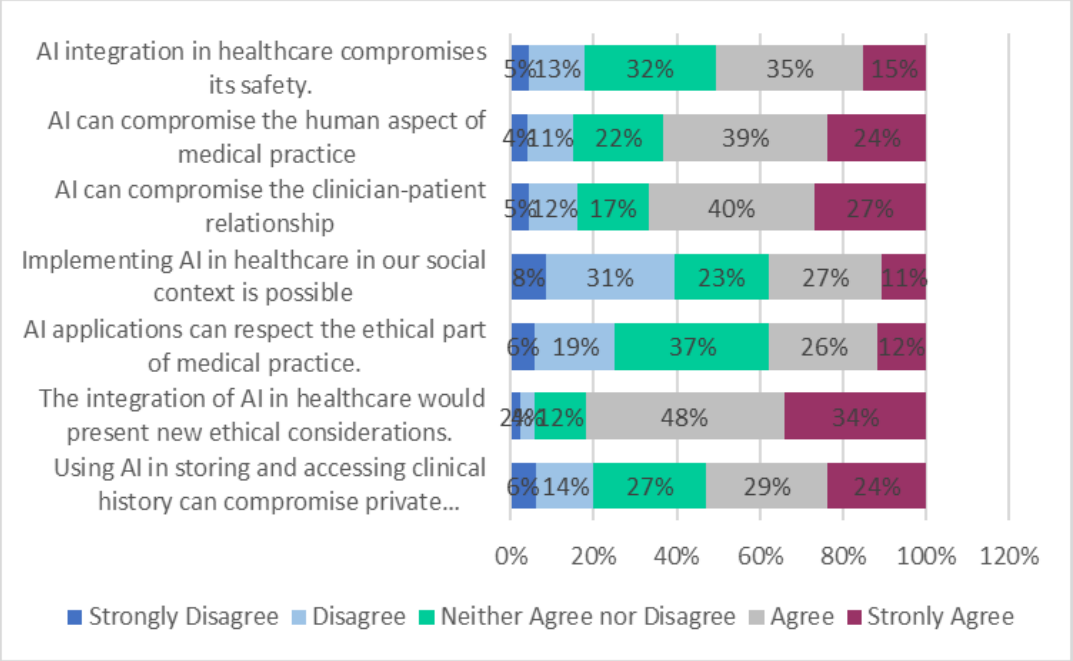

Figure 15: Rating of potential AI ethical implications and challenges.

Table 5: Rating of potential AI ethical implications and challenges.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
AI integration in healthcare compromises its safety	5% (14)	13% (41)	32% (98)	35% (110)	15% (47)
AI can compromise the human aspect of medical practice	4% (12)	11% (35)	22% (67)	39% (122)	24% (74)
AI can compromise the clinician-patient relationship	5% (14)	12% (36)	17% (53)	40% (124)	27% (83)
Implementing AI in healthcare in our social context is possible	8% (26)	31% (96)	23% (71)	27% (84)	11% (33)
AI applications can respect the ethical part of medical practice	6% (18)	19% (60)	37% (115)	26% (81)	12% (36)
The integrating of AI in healthcare could present new ethical considerations	2% (7)	2% (11)	12% (38)	48% (148)	34% (106)
The use of AI in storing and accessing clinical history poses a higher risk to patient privacy compared to traditional records	6% (19)	14% (43)	27% (84)	29% (89)	24% (75)

2. Liability of AI mistakes: Participants perspectives:

This question was multiple choice. All groups involved in the design, use and implementation of the AI system should have a joined responsibility was the most common choice with 72.6%. It was followed by the algorithm designers with 17.4%, then the device manufacturers with 15.5%. 10.6% of our respondents felt that the liability should fall on the hospital. Only 6.8% of our students felt that responsibility should fall on the healthcare professional.

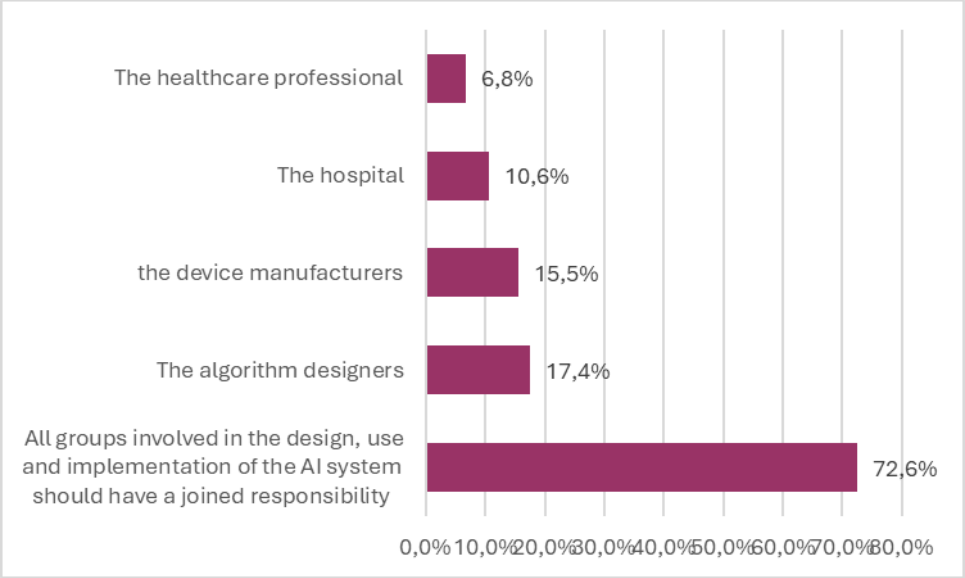

Figure 16: Liability of AI mistakes.

3. Future challenges of AI in Medicine: Participants perspectives:

We asked our students what future challenges of AI they thought would be harder to overcome. According to our findings, 66.5% of our respondents chose privacy concerns and data security, followed by transparency issues with 49%. Next was biased decision-making with a rate of 43.9%. 33.5% of our students indicated patients' confidence in AI devices and 30% chose liability implications. Only 22.6% of our students chose impact on the physician patient relationship.

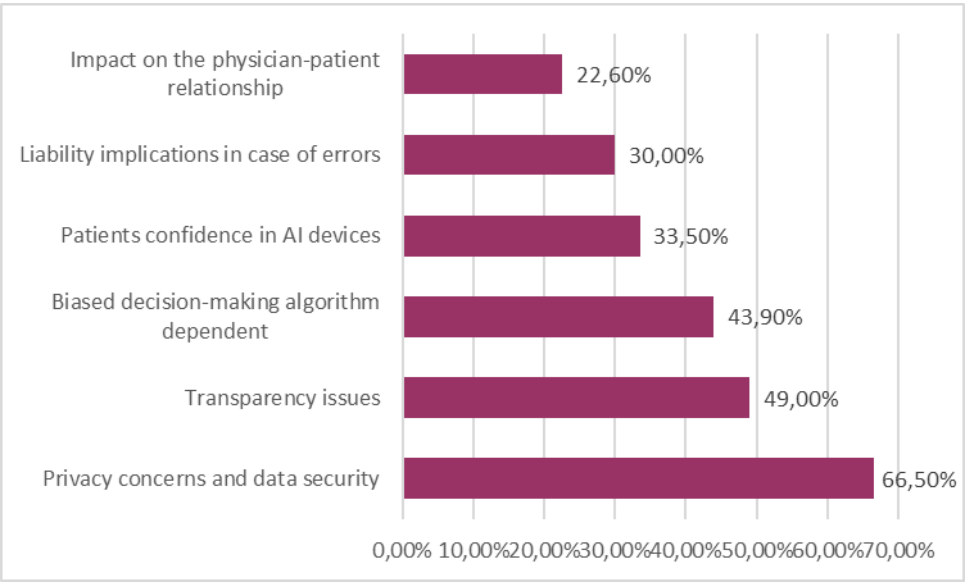

Figure 17: Future challenges of AI in medicine: Participant perspectives.

VI. AI in the medical education:

1. AI courses inclusion in the curriculum:

According to our findings, 60.1% of our respondents were in favor of AI being included in the curriculum (37.7% strongly agreed, 22.4% agreed). Additionally, 26.3% of our respondents were neutral (n=81), while 13.6% of our respondents did not feel like AI should be included in the curriculum (9.1% disagreed, 4.5% strongly disagreed).

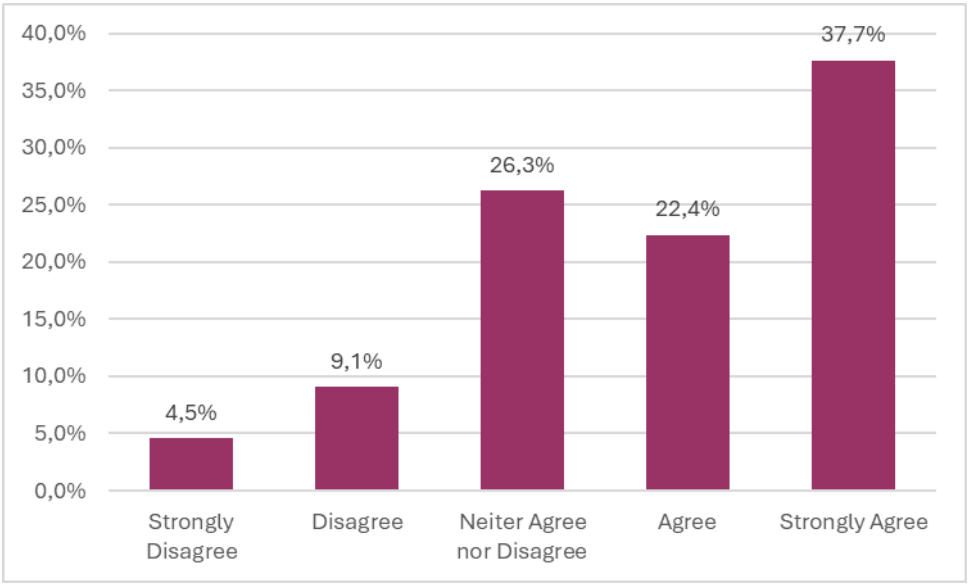

Figure 18: level of agreement with AI courses inclusion in the curriculum.

2. The right time to include AI education in the medical curriculum: Neutral/Agreement-based responses:

From the data we gathered, a total of 44.8% (n=120) of students believed that AI education should be included later in medical education, 36.9% (n=99) of the students believed that it should be thought earlier in medical education. We got a total of 16.4% (n=44) of students who weren't sure about the right timing. An option for other answers was included in the choices, 1.5% (n=4) of the students added that it should be taught throughout the whole curriculum. One student added that it should be an integral part of every module, not a distinct one by itself (0.4%).

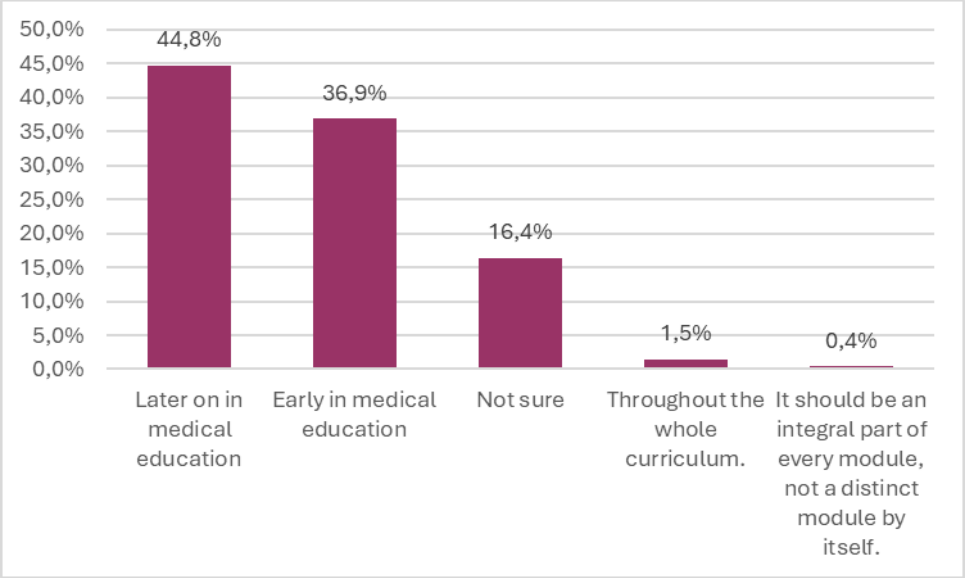

Figure 19: The time to include AI education in the medical curriculum.

3. AI education form of inclusion: Neutral/Agreement-based responses:

This question was multiple choice addressed to students who approved an agreement or neutrality concerning AI inclusion in the curriculum. 64.2% of our students were in favor of teaching AI via conferences and seminars, closely followed by online learning modules with 53.7%. AI education through lectures only got 29.1%. The option of practical classes and simulation sessions was added as another choice by our respondents representing a total of 4.5% of the answers.

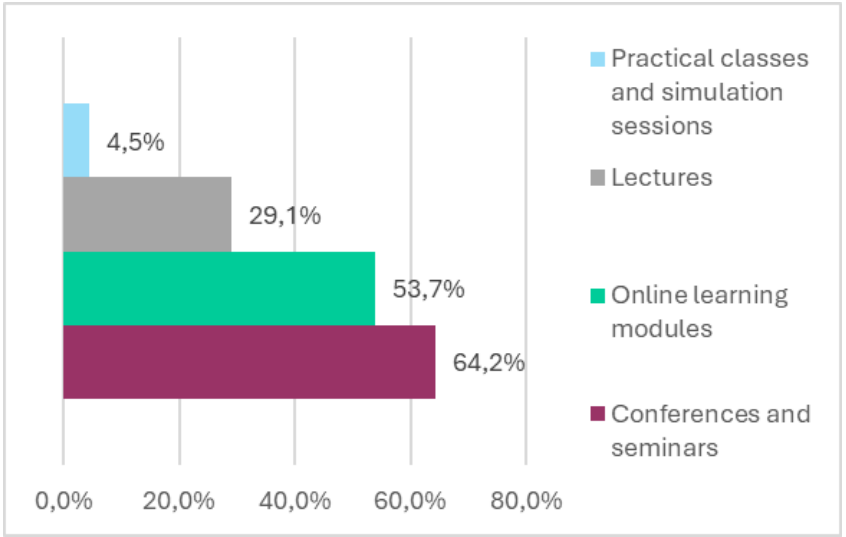

Figure 20: AI education form of inclusion.

VII. Correlation analysis between students' level of familiarity with AI applications in healthcare and their openness to adopt AI tools:

We tested the relationship between students' openness to using AI tools and their level of familiarity with AI applications in healthcare. A p-value > 0.05 was recorded. This suggests that there is no statistically significant relationship between the two.

Table 6: The relationship between students' openness to using AI tools and level of familiarity with AI applications in healthcare. Healthcare.

		Openness to using AI tools		
		Not open/ Neutral	Open	Fisher's exact test
Level of familiarity with AI applications in healthcare	No familiarity	55% (144)	45% (118)	0.521
	Moderate to extensive familiarity	54.2% (26)	45.8% (22)	

VIII. Results of open-ended questions and verbatim: Qualitative insights from respondents:

1. Suggested AI definition in case of disagreement with the given definition:

We proposed an open question to allow participants who disagreed with the suggested AI definition to provide their own interpretations. Some students suggested that instead of AI mimicking and being a replication of human behaviors and cognitive abilities, it's simply a tool that enhances human work:

- **''AI est la capacité des machines à booster et perfectionner le comportement et les capacités cognitives et pratiques humaines''.**

- **''C'est une série d'algorithmes plus ou moins complexes ayant pour but d'améliorer la capacité intellectuelle de l'humain sans la mimer à 100%''.**
- **''Les machines ne font pas que mimer le comportement et les capacités cognitives humaines. Ce sont des technologies qui ne font qu'améliorer la vie humaine en se servant de base des comportements et capacités des humains. Exemple une calculatrice peut calculer l'homme aussi mais l'homme ne peut pas calculer comme une calculatrice ! ''.**

Some students were mainly with the idea that AI is simply a machine that uses the data available to it to give the most probable answer without using intelligence:

- **''Une machine qui donne comme réponse le résultat le plus statiquement probable et qui est destiné à répéter bêtement les données fournies à elle sans lien logique ni capacités cognitives''.**

Others were more in favor of the opinion that AI can go far beyond what a human can do:

- **''La capacité des machines à SURPASSER le comportement et les capacités cognitives humaines. Ex: la mémoire''.**
- **''L'intelligence artificielle ne se limite pas à imiter les capacités humaines, elle peut les dépasser dans certains domaines, comme le traitement de données massives ou la rapidité d'exécution, elle est souvent conçue pour accomplir des tâches que l'humain ne pourrait pas réaliser aussi efficacement ou rapidement''.**

2. Suggested legal or ethical aspects that should be taken into consideration before integrating AI in the medical practice:

Some students thought it was imperative to have legal regulations on the use of AI in the context of healthcare:

- ''Ensuring that patient data is protected from breaches and unauthorized access is crucial, and compliance with regulations like HIPAA (Health Insurance Portability and Accountability Act) is essential''.
- ''Our country should work on a regulatory party to take care of all AI related issues and news''.
- ''Premièrement la protection des données et de l'anonymat du patient. Deuxièmement, des lois qui encadrent l'utilisation de l'intelligence artificielle dans le domaine médical. Troisièmement, une bonne formation du médecin qui pourra détecter les anomalies de l'IA afin de prévenir les potentiels fautes''.

Some students noted the importance of making medical related AI tools exclusive to healthcare and never for free access by the public:

- ''Putting limitations and making these devices exclusively to doctors and med students. It shouldn't go public at all''.

Some students emphasized the importance of taking all the necessary measures to insure the respect of ethics and patients' rights:

- ''Le consentement des patients, leur information complète, la possibilité de compromettre leur données (cyberattaques), la responsabilité du médecin en cas de faute médicale, le coût de cette intégration qui pourrait causer un plus grand gouffre dans l'accès aux soins pour les personnes nécessiteuses...''.
- ''Le consentement éclairé : les patients doivent être informés de l'utilisation de l'intelligence artificielle dans leur prise en charge et donner l'accord.''
- "L'équité d'accès : s'assurer que toutes les populations y aient accès sans inégalités en matière de soins ".
- "AI should not provide medical history of the patient to any person, only his registered doctor who can do so ".

3. Reasons for disagreement with the inclusion of AI courses:

Some students disagreed with the inclusion of AI courses because they think it is a tool that can be learned individually:

- **''For now, it could be learned elsewhere''.**
- **''Le programme est chargé et ces outils peuvent être appris via internet''.**

Others thought that the focus should be on other important subjects:

- **''Je trouve qu'il faut accorder l'importance à une bonne formation médicale plutôt que de condenser d'autres modules dont la relation avec la médecine et le soin des patients est -j'estime- faible''**

Some students believe that AI shouldn't be included in healthcare and as a result, they view studying AI-related subjects as unnecessary:

- **''In my opinion, AI shouldn't be implemented in the clinical setting/diagnostic process at all and could be limited to administrative tasks at most. So, implementing it in the curriculum would be of no use''.**

Some respondents reported that since using AI is optional, studying AI-related subjects should be as well:

- **''Je pense que l'intelligence artificielle peut être utilisée comme étant un outil au clinicien et au futur médecin généraliste, et donc le médecin a le choix de l'utiliser ou pas, et donc il doit aussi avoir le choix s'il veut ou ne veut pas avoir un cours en rapport avec l'IA''.**

4. Suggested AI-related topics that should be part of the medical curriculum:

We asked to students to suggest AI-related topics they thought should be included in the curriculum, here are some of the answers:

- "How can doctors combine AI and classical medicine".
- ''Les bases de IA/ les applications de IA en médecine (interprétation des images/analyse biologique...)''.
- ''Introduction à l'IA en médecine, éthique de l'IA en santé, validation des algorithmes d'IA, interprétation des résultats d'IA et prévention des biais algorithmiques''.
- ''Introduction à l'IA en Médecine, science des données en santé, outils de diagnostic prédictif, recherche et innovation en IA médicale''.
- ''Son usage médical actuel dans les différentes spécialités ainsi comme étant un outil d'apprentissage, même si ça paraît simple plusieurs professionnels de santé et étudiants sont mal informés en ce qui concerne les applications fréquentes de l'IA en médecine''.
- ''Surtout la recherche et les méta-analyses''.

5. Opinion on the use of chat-bots and LLMs in medical education:

We asked the students about their views on the use of chat-bots or virtual assistants and LLMs in medical education. Some students thought that it might be beneficial to their education. It could provide faster access to information and personalized answers, therefore facilitating self-learning. It was noted that with digitalization on the rise, it is best for them to familiarize themselves with the different tools sooner than later:

- ''I think that using LLMs is a nice addition to our arsenal as medical students''.
- ''L'utilisation des chat-bots ou assistants virtuels dans l'éducation médicale peut enrichir l'apprentissage en offrant un accès rapide à l'information, des réponses personnalisées aux questions et des simulations''.
- ''Les chat-bots peuvent être disponibles en permanence, ce qui permet aux étudiants d'accéder à des informations ou à des réponses à leurs questions à tout moment, même en dehors des heures de cours ou de travail. Cela facilite l'apprentissage autonome et soutient les étudiants qui ont besoin d'une aide supplémentaire''.

- ''Je suis tout à fait d'accord, À un moment donné les médecins se retrouveront face à un nouveau système de travail totalement numérique C'est pour cela qu'on doit intégrer ces logiciels dans leur formation''.

Others remarked on the usefulness of these tools but with emphasis on the importance of rational and intelligent usage:

- ''I think they can be useful in getting information, but whether the source is reliable or not the person using AI should always check for that unless they make a chatbot dedicated to medical education and has the latest guidelines''.
- ''Les chatbots et assistants virtuels peuvent être d'excellents outils complémentaires pour enrichir l'éducation médicale, surtout en termes d'apprentissage théorique, de révision et de simulation clinique. Cependant, ils ne devraient pas remplacer l'apprentissage traditionnel ni les interactions humaines cruciales à la formation des médecins, et une attention particulière doit être accordée à la qualité des informations fournies !!''.
- ''Ils sont mieux que les moteurs de recherches qui se base sur crawling and indexing ; ils sont plus précis mais bien sûr on remarque parfois des fautes dans les réponses de chat-bots et aussi de manque d'information surtout dans les nouvelles recherches médicales''.
- ''Je suis avec son utilisation, le monde progresse on ne peut pas être passifs et ne pas utiliser tous les moyens pour faciliter notre apprentissage, mais on doit savoir comment bénéficier de ces chatbots et assistants par exemple engendrer des stimulations de cas cliniques, nous aider à comprendre des notions sans oublier l'utilité de nos chers professeurs je pense que ça va faciliter les tâches pour eux et nous et aussi sans trop être dépendant et attendre que AI fait le travail à notre place.''.

We also perceived some level of disagreement among the students, stating that chatbots are not reliable tools:

- ''I'm against the idea, medical knowledge should be based on fact-checked resources, not an algorithm that skims through different and potentially unreliable resources and generates combined results that are prone to error''.
- ''Ils sont bien mais pas très fiable pour l'instant. Plusieurs personnes ont uniquement accès à des versions gratuites qui sont moins fiables''.

DISCUSSION

I. Brief history of AI in medicine:

1. Birth of artificial intelligence:

The earliest work in the field of AI was the concept of a mathematical neuron, or the MCP neuron (McCulloch and Pitts neuron). It was presented in 1943 by neuroscientist Warren McCulloch and logician Walter Pitts. The MCP neuron (figure21) is defined as an electronic simplified binary model representation of a biological neuron (figure22). It represented a simple computational model. It could do basic logic and extract complex outputs from simple units and played a role in the development of artificial networks [13].

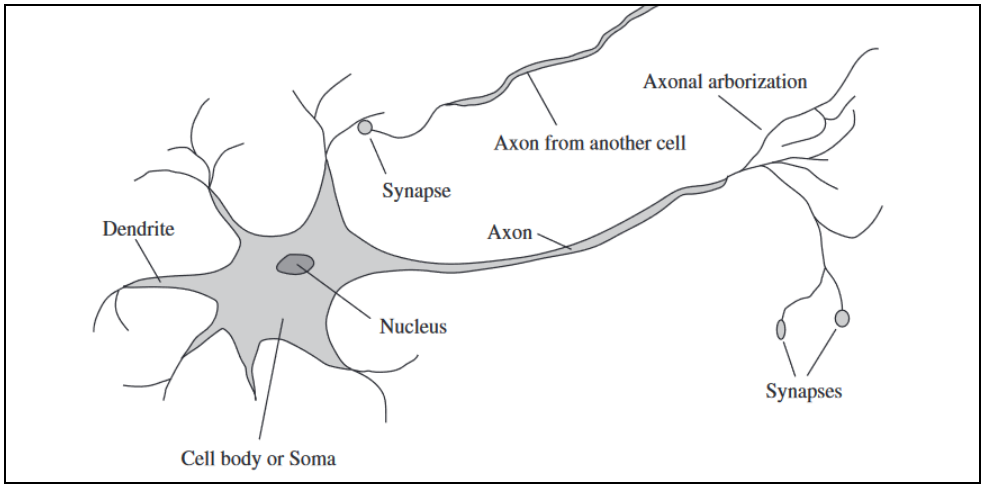

Figure 21: Biological neuron [14].

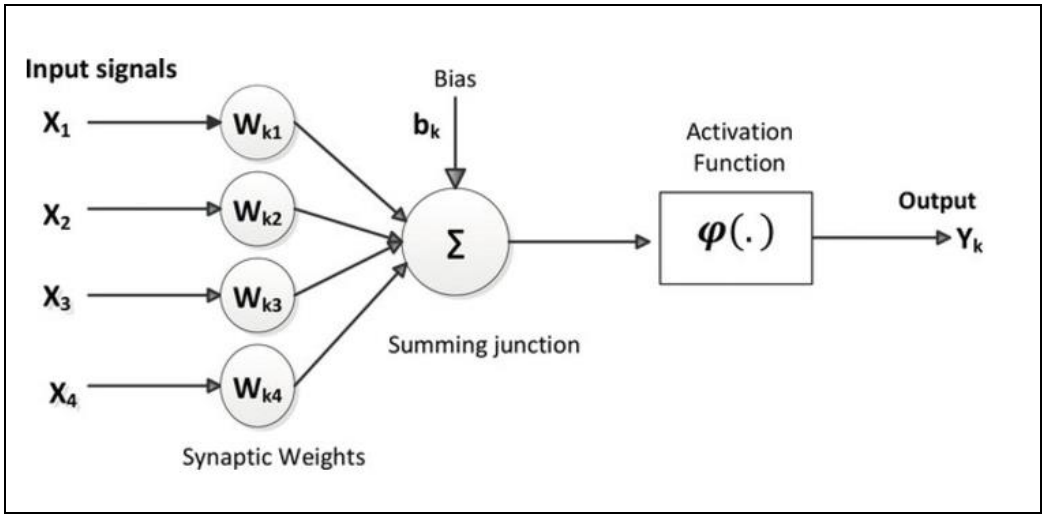

Figure 22: MCP neuron [15].

There were some early attempts at what we now call artificial intelligence. However, mathematician and logician Alan Turing's theory was arguably the most influential. In 1950, he first described intelligent machines in a study known as the Turing test that generated great discussions on its potential [14].

By 1951, researchers designed the SNARC (Stochastic Neural Analog Reinforcement Computer), the world's first neural network computer [14]. It was the fruit of a collaboration of 2 Harvard graduates at the time: computer scientists Marvin Minsky and Dean Edmonds. The SNARC was designed to simulate a network of 40 neurons [14]. Additionally, this neurocomputer was made to learn and improve. It used a process of trial and error for reinforcement learning. The SNARC represented one of the earliest electronic learning machines [16].

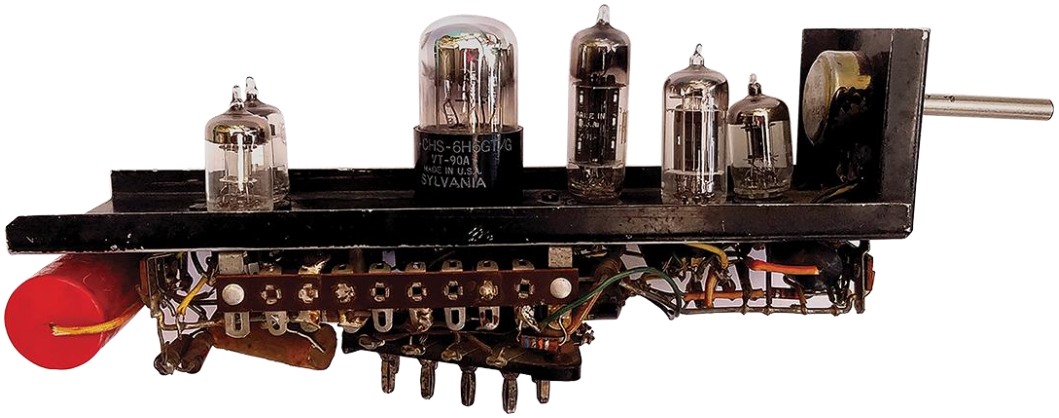

Figure 23: Stochastic Neural Analog Reinforcement Calculator[17].

However, the term "artificial intelligence" was only officially coined 13 years after the MCP neuron was published. It happened at the Dartmouth conference [1]. In 1956, John McCarthy and other associates organized a study of artificial intelligence. It included 10 researchers with a duration of 2 months. The study was based on the grounds that intelligence can be broken down into parts that a machine can learn. These include language, understanding of abstract concepts, problem solving, decision making, reasoning and self-learning [14]. The conference didn't yield many breakthroughs. However, it created the field's official name.

2. The 1950s to 1970s:

The goal of early AI was to create machines that could make decisions only humans could. In 1957, computer scientists Allen Newell and Herbert A. Simon developed the world's first AI program, the general problem solver (GPS) [18].

After that, the first robotic arm, Unimate, was introduced in 1962 [19]. It was invented by George Devol and marketed by Joseph Engelberger. Unimate was installed, that same year, in the General Motors factory to extract pieces from a die-casting machine [19]. By 1965, computer scientist Joseph Weizenbaum had developed one of the earliest natural language processing programs called ELIZA [20].

Another remarkable milestone was the SHAKEY project. It was a robot fabrication attempt by the Stanford Research Institute, from 1966 to 1972. It was equipped with a television camera and sensors. The robot was an impressive innovation despite the computing limitations at the time. Computers were too large, and TV cameras were poor. Tasks execution took too long, and it couldn't do real-life tasks. However, It still represented a progressive innovation and an important pillar in robotics [20].

Regardless of these technological advances, medicine was slow to adopt AI. However, this early AI progress was crucial for data digitization. They formed the basis for its growth in medicine [18]. The global access to biomedical information, from the literature via PubMed, since the 1960s, played a major role in pushing biomedical advancements [21].

3. AI first winter:

AI had gained a lot of hype by this point. AI pioneers promised breakthroughs in language, reasoning, and robotics. But, by the 1970s, it became clear some claims were too optimistic. While scientists managed to make some AI applications primarily for playing games. This includes Arthur Samuel's checkers program and the Machack chess program. It failed to deliver on promised general AI [20].

By the early 70's, the Science Research Council commissioned British mathematician Professor Sir James to review the state of AI research breakthroughs in the UK. The report was published in 1973, after a thorough assessment of the state of progress. Lighthill disapproved of the lack of breakthroughs on the subject. He reported that a distinct AI field was unnecessary. The report led to a decrease in support from the UK government and withdrawal in funding [20] .

The US AI research, financed by the military agency (DARPA), parallelly witnessed a drop in funding due to unfulfilled promises. This decline in financing and disappointment in the field led to a dark period for AI research from 1970 to the early 1980s. It was later named the first AI winter [20].

4. The rise of artificial intelligence expert systems and artificial intelligence in medicine (AIM):

Despite the decline of interest in AI systems, collaboration among AI enthusiasts continued. In the 1970s, new methods for using computers to represent expert knowledge gave rise to artificial intelligence in medicine (AIM) [21].

During that period, scientists knew they had to shift their areas of interest into more restricted intelligent machines with intensive knowledge, instead of the more general AI that was still weak. This sparked attention on expert systems. Such programs functioned by simulating human-like reasoning within defined areas [1].

INTERNIST-1 is an example of these expert systems. It was developed in 1971 at the University of Pittsburgh. It aimed to help clinicians diagnose internal medicine cases by analyzing a patient's history, exam results, and lab work. INTERNIST-1 was a model of symbolic reasoning and an example of physician modeling in a computer system. The program operated with a knowledge base of 500 diseases and 3550 symptoms [22].

Another example of an expert system at the time is the DENDRAL heuristic program. It was first introduced around 1972 at Stanford University. Biomedical researchers Joshua Lederberg and Carl Djerassi, along with AI researchers Edward Feigenbaum and Bruce Buchanan, de-

veloped it. The designers created the program to execute chemical analysis [23]. It also helped chemists find the structure of organic molecules by using expertise of skilled chemists in the form of expert systems [23]. DENDRAL's success proved AI can mimic expert judgment in particular fields. It also encouraged the development of other systems. For example, a team at Stanford, led by Brace Buchanan and Ted Shortliffe, created MYCIN in 1972. It was a collaboration of AI and medical research [24]. It's an expert system whose name is derived from the suffix -MYCIN. Created as a tool to help junior doctors, MYCIN functioned by the use of predefined if-then rules and deduction methods to diagnose infectious blood diseases [25]. It benefited from the expertise of its fabricators, as a result, they were not impacted by the costly service of hiring experts to incorporate knowledge into heuristic systems. MYCIN included a base knowledge of around 450 rules [1].

The success of the expert system MYCIN led to the creation of EMYCIN. It performed as an empty canvas expert system. Launched at Stanford University in 1979, EMYCIN is an application with the same reasoning capacities as its sister application but without the base knowledge. It represented a template for creating expert systems in other domains [25].

Another attempt at applying AI in medicine is expert system CASNET. It was created in the 1970s. CASNET is a network that used its knowledge base to identify the relationship between diseases, symptoms and underlying conditions. Moreover, it could guide physicians in patient management, by applying its knowledge to specific patients. At Rutgers University, CASNET was used to develop an expert system for the diagnosis and the treatment of glaucoma [18,26].

Additionally, in 1980, the first AI application in radiology in the form of computer aided system was created. It was developed by a group of radiologists and medical physicists from Chicago's university department of Radiology. The application used computer vision and image processing methods to confirm a diagnosis or provide a second opinion [27,28].

In 1986, the University of Massachusetts created Dxplain [29]. The decision support system was the fruit of a collaboration between computer scientists, medical professionals, and re-

searchers at the university's general hospital laboratory. The program was designed to help medical professionals with diagnosis. Its function was to generate a list of possible diagnosis and differentials. This was done based on the submitted data of symptoms, lab results and patients' information. The program also served as a teaching tool for medical students by providing detailed information on diseases [29,30].

5. The second AI winter:

By the early 1990s, the field of neural networks faced a decline due to the limited computational advancements at the time. Furthermore, the limited demand of expert systems also played a part in this downfall. Expert systems were expensive due to the need for experts to input their knowledge. Their costly nature along with the lack in demand made their adoption challenging [31,32].

6. Resurgence of AI interest: early 2000's to current day:

The interest in artificial intelligence experienced a resurgence by the early 2000s. It was led by advances in computing power. It could now support the development of neural networks [31]. An example of these advancements is IBM's 1997 chess-playing supercomputer, DEEPBLUE. It managed to beat Garry Kasparov, the world's champion in chess at the time. This feat raised IBM's stock and reignited debate around intelligent machines. Then, IBM proceeded to develop Watson in 2007. In 2011, it beat top players on Jeopardy. It was an example of an open-domain question system, a software that processes natural language to answer complex questions [20].

After Watson's success, BMI took on a new challenge of applying the DeepQA technology to medicine [33]. As we discussed, up to this point AI application in medicine relied mainly on expert systems. These programs used backward or forward reasoning or if-then rules for their knowledge base. Experts in a specific domain must manually input knowledge into these systems. This process can be costly to maintain as new knowledge and guidelines continue to be updated. DeepQA, unlike expert systems, can use unstructured data. It does this via natural language therefore making it easier to manage [33].

For example, in 2017, researchers at Barrow Neurological Institute, Phoenix, and the BMI team collaborated on a work using BMI's Watson. They aimed to find new RNA-binding proteins (RBPs) that contribute to amyotrophic lateral sclerosis (ALS). The program was used to analyze past publications and clinical data to find new links and proteins related to ALS's causes. The analysis ranked all RBPs in the genome. It used their similarities to known ALS-related RBPs and their participation in the pathogeny of ALS. This minimized the target list of potential ALS-related RBPs. Afterwards, researchers used several methods on the nervous systems of people with and without ALS. These methods included immunohistochemistry, RNA, and protein analyses. This approach proved the link between 8 of the top 10 genes ranked by Watson. Researchers also tested three of the lower-ranked RNA-binding proteins, finding that they remained unaltered. This outcome served as a negative control [34].

The AIM landscape has exploded in recent years, with over 100 start-ups emerging globally since 2018. Notable examples include IBM's Watson Health, Tencent's Miying Medical Laboratory, and iFLYTEK's Smart Medical Division[4]

The tech advancements of this era, from computers to data storage, and the rise of natural language and deep learning, have made AI's integration into medicine an eventful event.

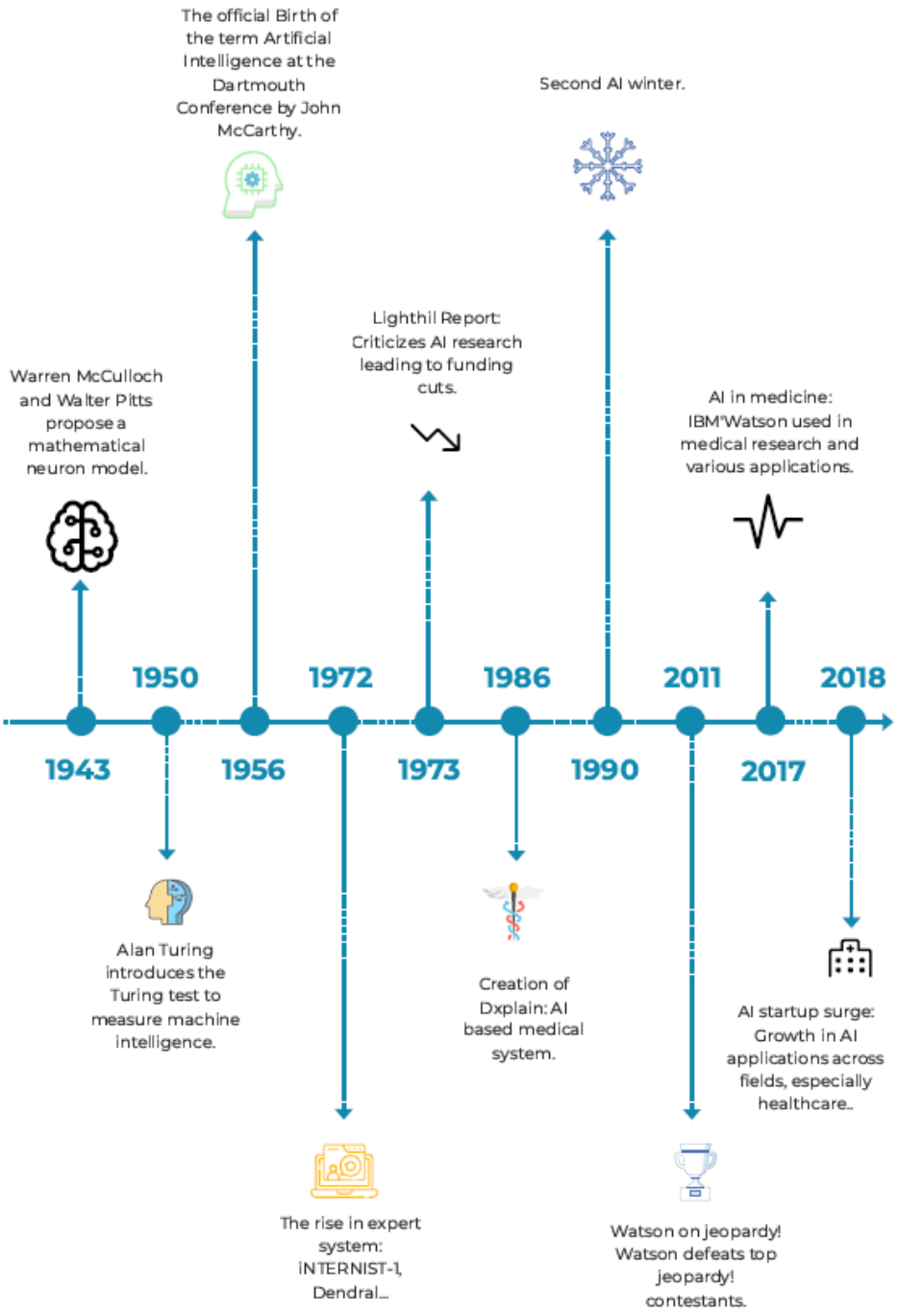

Figure 24: A timeline for AI history.

II. Definitions and terminology:

1. Artificial intelligence:

1.1. Types of artificial intelligence:

- Artificial narrow AI: Also known as narrow AI or applied AI trained on a specific dataset to perform a certain task or a set group of tasks [35].
- General AI: Also known as strong AI, is a theoretical type of AI scientist aim to create, it is intended to replicate human cognitive capacities [35].

2. Neural network:

A neural network is a machine learning model, that was created to process input in the same manner as a human brain. It consists of layers of artificial neurons where the first layer represents an input layer followed by other hidden layers and finally an output layer. Each layer of artificial neurons contains a weight and a threshold, and it's all connected. When the data is inputted, the layer of node adds the set weight and then depending on whether it exceeds the threshold or not the node is either activated sending information to the following layer or it doesn't activate and therefore the data isn't passed [36].

Neural networks can be divided into shallow neural networks and deep neural networks.

1.2. Shallow neural networks:

It refers to a simple neural network consisting of one input layer and one output layer separated by a maximum of one hidden layer. The simple model is simple to train however it doesn't apply to complex problems. Some of the applications of these type of neural networks are task classification and linear regression that model relationships between different variables [37].

1.3. Deep neural networks:

It's a network with input and output layers separated by many hidden layers allowing the model to function on more complex patterns. These neural networks are applied in natural language processing, such as chatbots and translation devices, as well as image and speech recognition [37].

3. Machine learning:

Machine learning is a subfield of artificial intelligence focused on developing computational models for the learning process and using data and algorithms to build learning machines without needing external intervention by humans [3]. We can divide machine learning into the following classes:

- **Supervised learning:** This is the most widely used AI algorithm class [4]. It is a method of learning that uses classified datasets, with paired input-output to help train algorithms in categorizing data and making predictions on the outcomes [4,38].
- **Unsupervised learning:** It is a method of leaning that analyzes and groups unlabeled datasets using machine learning algorithms in order to find hidden relationships or patterns in the data without requiring human assistance [38].
- **Semi-supervised learning**: It represents a medium ground between supervised and unsupervised learning that uses some of the labeled data among a larger number of unlabeled data. The labeled date plays a role in setting the classification for the unlabeled date [38].

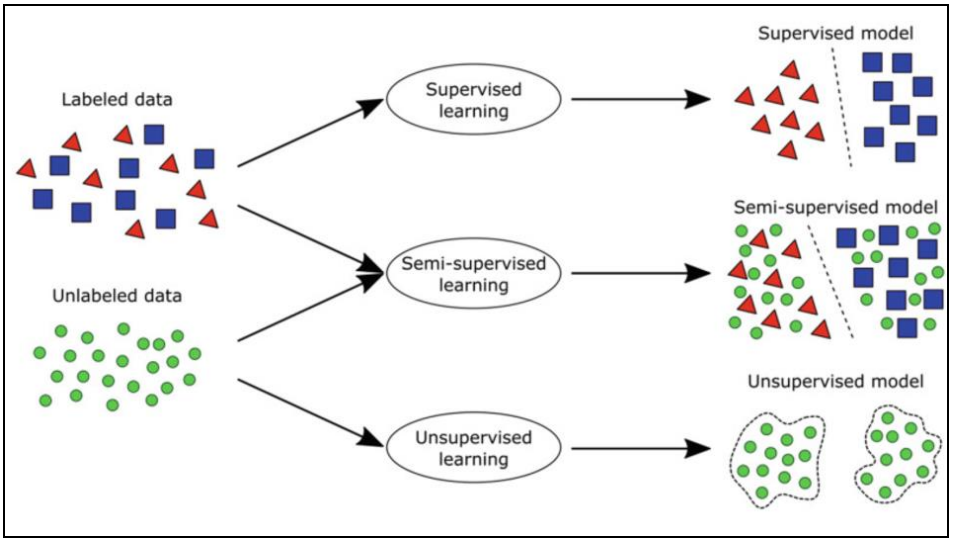

Figure 25: Types of machine learning: Supervised, unsupervised and semi-supervised[39].

4. Deep learning:

Deep learning is a subset of machine learning powered by artificial neural networks that allows computers to learn from experience by using multilayered neural networks to replicate human decision making capacities [40].

5. Natural Language Processing (NLP):

Natural language processing is a branch of artificial intelligence, its main goal is to allow computers to comprehend and communicate generate speech in natural language [41].

6. Language models or LLMs:

Large language models or LLMs are a class of AI developed by being trained on an immense amount of data. This gives it the capabilities to understand and generate natural languages, as well as many other forms of content [42].

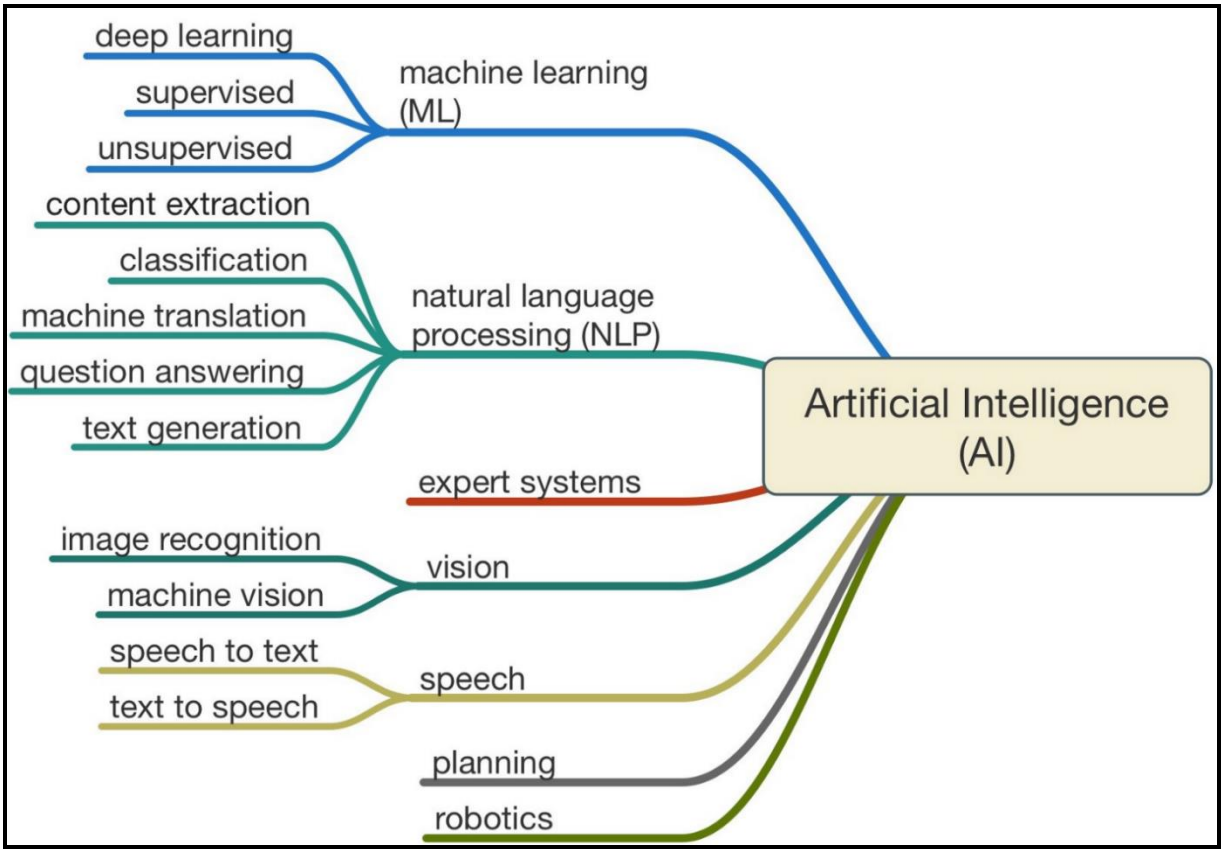

Figure 26: Schematization of the different fields of artificial intelligence [43].

7. Big data:

Big data is a term used to describe datasets that are too large or complex to be processed by traditional data processing applications. Such datasets are often characterized by three Vs: volume, velocity, and variety [3].

III. Applications of AI in medicine:

1. Artificial intelligence applications in radiology:

Radiology is one of the specialties that gained remarkably with the advancement of technology, the rise of deep learning and convolutional neural networks has made a great impact on the field.

AI-powered computer aided detection systems are an example of AI implementation in radiology. CAD systems use specialized software in order to identify and highlight suspicious areas of tissue. This technology is employed in various imaging tools such chest x-rays or mammography, so as to aid in diagnosing diseases [44].

Since the screening for breast cancer with mammography has taken more of a digital form, there has been rise in computer aided detection technology in the early 2000. Over the past few years, the field of image analysis has witnessed a significant advancement. The introduction of convolutional neural networks(CNN), with its ability of analyzing visual data exhibited an improved level of accuracy concerning breast cancer detection [45].

A comprehensive review of the Implementation of AI in breast cancer screening showed an improvement level in the sensitivity while parallelly lowering the percentage of false positives [45]. Additionally, in an international study evaluating the use of a deep leaning model for identifying breast cancer on two datasets in the UK and USA, it showed that the implementation of AI in the screening displayed a decrease in misdiagnosis rate as well as a workload relief on the second reader of about 88% [46].

The importance of AI in radiology mainly relies on it being a big data specialty, its accessibility in the field would allow the implementation of radiomic analysis systems , exploiting the various images in the medical field from X-rays, CT scan , pets scans and IRM images…[47]

2. Artificial intelligence in pathology:

With the advancement of technology, and pathology taking more of a digital form, it managed to build an electronic dataset of digital images enabling its use for clinical purposes, as well as the potential of applying AI in pathology for diagnostic purposes based on image analysis [48]. Whole-Slide Imaging played an enormous role in the informatization of images in high resolution for many potential uses such as machine learning processing, deep learning algorithms [49].

Deep learning in histopathology uses recognition image analysis systems to pinpoint regions of interest in images by applying learned information, such as spatial and spectral features, in order to analyze new input. But many of these applications need a large reliable data source for learning, which is currently a limitation, because the efficacy and potential of the algorithms mainly depends on the quality of the knowledge base or dataset [48].

There have been some recent studies focusing on implementing deep learning into the most common types of cancer such as prostate breast and lung cancers. A study named CAMELYON16 evaluated 32 deep learning algorithms in detecting metastases in lymph nodes of woman on H&E slides of lymph nodes. It found that 7 of the used algorithms managed to perform and show better distinguishing ability in comparison to a group of 11 pathologists on a time constraint [50].

Another study conducted by Campanella et al. introduced a deep learning model based on the multiple instance learning (MIL) technique. This approach uses general diagnostic labels rather than detailed image annotations. The system was tested on three types of cancer: prostate cancer, basal cell carcinoma, and breast cancer metastases in lymph nodes. The results demonstrated the system's capability to differentiate between healthy and diseased tissue as well as

eliminate non-essential slides by 65 to 75 % with a 100% sensitivity, ensuring that all cancer cases are identified without missing any [51].

These applications open a door to a more flourishing future to train high-precision deep leaning models and implementing AI-driven systems within clinical practice in real life to support decision-making processes.

3. Artificial intelligence in surgery:

Advancements in artificial intelligence (AI) will significantly transform surgical practice, aiding preoperative planning and intraoperative performance.

AI-powered tools can evaluate risks by analyzing factors that are related to patients and operations[52].

It also offers potential Intraoperative assistance. By using computer vision, AI powered tools can read, segment, and analyze surgical videos. This can provide a rich global dataset for AI computer vision algorithms. However, the dynamic nature of surgical videos character of surgical videos and the absence of labeled data and the unavailability of standards of surgical steps complicates AI tool development in this field [52].

Guidance during surgery has the potential to provide accurate visual assistance for surgeons in challenging operations, powered by the experience of experts globally. Ongoing research in this area is directed towards using Deep learning models for surgeries to accurately define dangerous areas with a remarkable degree of performance [52].

AI-assisted 3D reconstruction can be useful in preoperative planning and intraoperative navigation when conducting complex operations. The FDA-approved cloud-based surgical AI tool Cydar EV Maps (Cydar Medical, UK) can generate a patient-specific map that illustrates the arterial anatomy, employing anatomic mapping preoperatively and real-time fluoroscopic imaging [53].

Robotic systems can also offer several advantages in surgery, such as a higher procedural performance, better coordination, and a realistic magnified three-dimensional view [52].

Deep learning can be integrated into convolutional neural networks to enable the automation of objective skill evaluation of basic technical surgical tasks, such as suturing or knot tying from video data. This could standardize the assessment of surgical tasks at the novice stages, diminish subjective bias in feedback, and eliminate the time-consuming process of manual expert evaluations [52].

Robotic systems, like the Da Vinci system, function in a model in which the surgeon is completely in control and the robot replicates every motion they perform. Currently, the systems we dispose of can only achieve either task autonomy or conditional autonomy. Fully autonomous robotic systems capable of performing surgery "from incisions to closure" are conceptual for now [52]. The developments of AI in surgery are still in the initial stages. AI-powered tools already show promise in enhancing this field.

IV. DISCUSSION OF OUR RESULTS:

1. Students' perceptions on AI definition:

The given definition was the following: Artificial intelligence (AI) can be defined as the capacity of machines to imitate or replicate human behaviors and cognitive abilities [2].

The high level of students' agreement (83.9%) strongly supports the definition we proposed. This might mean that it is relevant to their perception of AI. Yet, a 16.1% disagreement rate suggests the existence of other views that could be explored.

Students' open-ended responses showed a range of views on their perception of AI's nature and role. While analyzing the open answers, we noticed the emergence of three principal themes. Some students perceived AI as a tool to enhance, not replace, human intelligence. Others expressed skepticism around the intelligent part of the definition. They argued that AI is a data-driven technology. It processes information through algorithms without showing any proof of cognitive abilities. The third group perceived AI's capabilities as superior to those of human nature.

The unclear definition of intelligence has sparked debates on the basis of AI. Some define it as the capability of performing similar tasks to human beings. Others consider conducting simple cognitive tasks sufficient to label a machine as intelligent. A notable trend was observed with the rise in technology: As machines take on more tasks, our criteria for what makes it intelligent become stricter [54–56].

Students might cite machine learning's quick data processing as a benchmark for AI's superiority. However, it's important to remember that current AI can only execute or automate some tasks. The only type of AI currently available is the narrow type. The quest for achieving artificial general intelligence (AGI) remains an ongoing pursuit [57,58].

AI's definition has shifted over time. For many, the lack of a clear definition isn't a major drawback. As the field is still evolving, its boundaries will only get clearer with time. However,

some argue that a clear definition is important. It sets goals and boundaries for evaluation, which is an important step for measuring progress. Even though a precise definition of artificial intelligence can be elusive, it holds significant advantage in the evolution of research. It allows clarity in discussion and biases mitigation. Thus, the importance of putting effort into establishing a clear agreed upon definition [59,60].

2. Students' level of AI Knowledge and familiarity with its applications in healthcare:

1.1 Students' level of AI knowledge:

Regarding students' level of AI knowledge, the overall distribution shows that a mere 14.6% of the students perceived their knowledge to be adequate or high.

These findings align with observations of medical students in other countries. A study by Liu et al. found that only 13.9% of US medical students understood basic AI terms and concepts. Tung et Dong reported that 30.9% of Malaysian students were confident in their understanding of computational principles of AI. Another example is a global study by Busch et al. It evaluated medical, dental and veterinary students' level of education and knowledge of AI. It was reported that 24.74% of students had good or expert knowledge [8,61,62].

Although we note varying degrees of general knowledge across the different studies, the overall assessment notes students' lack of confidence in their AI knowledge.

1.2 Students' familiarity with AI applications in healthcare:

Our findings regarding students' familiarity with AI applications in healthcare reveal that medical students have a significant knowledge gap, similar to the general AI level of knowledge. Only 15.6% noted adequate or extensive familiarity with AI in the medical context. Our results are consistent with observations in other studies. A study by Tahseen et al. found that merely 28% of students understood AI's healthcare applications. R et al. reported a rate of 26.4%. Additionally, Wood et al. reported that 30% of students were aware of AI topics relevant to medicine [63–65].

Our findings suggest a lack in generalization of information concerning AI and its domains of application in healthcare. It also indicates a need for more education amongst the stu-

dents in order to improve their familiarity with its potential in medicine. Pinto dos Santos et al. noted that understanding of AI lowers fears about its use. Thus, a lack of knowledge could slow its progress in clinical settings [11,66].

3. Students' attitudes regarding the application of artificial intelligence in the medical field:

3.1 Openness to using AI diagnostic tools:

Students were split on using AI diagnostic tools. 45.2% were open to it, and 43.2% were unsure.

We checked for a link between students' openness to use AI and their familiarity with the topic in healthcare. No statistically significant relationship was found between the two. These findings suggest, as a likely reason, students' hesitance to accept change, rather than a lack of information about AI in medicine. Historically, resistance has been recorded as a major obstacle to successful healthcare information technology (HIT) integration [67].

In contrast with our study, Pucchio et al. reported that 72.9% of the students were open to using AI applications during their careers [68]. Furthermore, Liu et al. reported that 79.3% of students looked forward to using AI as future physicians. The difference could be due to varying education and knowledge of AI. It could also be due to regional differences in exposure to AI technology as well as a general openness to HIT.

3.2 Potential delegated tasks:

There's a growing interest in AI in the medical field, showing promise in many medical applications. Tasks like patient monitoring are important in healthcare, whether in intensive care units, emergency rooms, medical or surgical wards and operating rooms etc. Monitoring devices generate large amounts of data that can be useful if combined with AI's alert systems. For example, factors such as age, gender, blood tests, heart rate, and blood pressure can be used to anticipate cardiac arrest, or hypoxemia in operating rooms. Deep learning algorithms can also analyze patients' monitoring data to draw predictions and suggestions on decision making [6,69–71].

Electronic health records and their integration in medical care generate data that can power clinical research. These datasets can be analyzed using natural language processing software to draw information from electronic health records (EHRs). Additionally, AI solutions offer the potential to automate history-taking, in order to organize data, actively interpret and contribute to generating new knowledge. It's reported that AI-powered history taking allows healthcare professionals to focus on core medical responsibilities, as well as enhance medical care. AI can also be used to automate tasks such as medical prescription, by identifying medication, calculating the dose and checking for drug interactions. Moreover, it offers the ability to enhance prescription accuracy and analysis [72-74].

In our study, the potential delegated tasks chosen the most were health files recording (87.1%), history taking (63.9%) and patient monitoring (61.3%). Tasks that require more human judgement were relatively less chosen, such as medical prescription (20%), diagnosis and medical decisions (12.9%). The results suggest students' inclination to delegating generative tasks more easily.

In a study validating general attitudes towards artificial intelligence in the United kingdom, it was reported that participants viewed AI more positively when it came to repetitive/big data fields while they had more of negative view when it came to AI being implemented in tasks requiring judgment [75].

3.3 Implementation plan regarding the use of AI:

Most respondents favored AI in an assistive role while the clinician fully retains control over the final decision. It included 42.3% of students preferring that AI -based tools help in decision but not to control electronic health records (EHRs) and 54.8% for AI having autonomy over EHRs. This suggests a desire to balance the benefits of AI with the requirement for human control in varying degrees. The results show a strong preference for a hybrid AI plan in healthcare in which clinicians make decisions, with AI providing support. It highlights the fact that implementing artificial intelligence in healthcare can improve decision-making. But, it also reflects the need for human judgment and expertise [76].

This hybrid approach shows an understanding of AI's limitations and a commitment to patient safety. Students seem to acknowledge that human expertise is a crucial part of guaranteeing the appropriate application of AI in order to insure clinical needs. Instead of completely eliminating physician involvement, it is suggested to direct medical professionals' skills on areas where they are most important and on tasks that computers cannot perform [5,77].

3.4 Perception of potential AI applications and influence to improve healthcare:

The Likert scale statements assessed students' views on AI's impact on healthcare. This study shows that medical students see AI's potential in healthcare such as improving medical decision, access to knowledge, and personalized treatments. They acknowledge its potential to also help with patients' health education and hospital management.

3.4-1 AI's role in enhancing medical practice:

Most medical students in our study (84%) expressed enthusiasm towards AI's potential to enhance the medical profession. These findings are consistent with a Canadian study on medical students by Pucchio et al. It found that 74% of students believed that AI has improved medical practice and could revolutionize medicine. Another study by Ejaz et al. had slightly higher findings with 94% of respondents reporting that AI can improve medicine [78].

91 % of our students believed that AI tools and medical chatbots can make medical knowledge and information access easier for clinicians. It goes in accordance with a Turkish study by Civaner et al. It found that 85.8% of students noted that AI can help doctors access information [79].

Additionally, 61% of students expressed agreement that AI could assist physicians in making more accurate medical decisions. Jackson et al. reported that 72% of students shared the same belief [10].

Although there is a slight difference in the findings, both studies demonstrate a positive perception of AI's potential to enhance diagnostic accuracy and decision-making in the medical field.

3.4-2 Improving medical outcomes:

63% of our participants thought that AI can reduce medical errors in healthcare. Other studies reported similar opinions, with 70.5% and 72.3% of students in the Civaner et al. and Jackson et al. studies, respectively, sharing this view [10,79].

3.4-3 Patient care and accessibility:

76% of our respondents believed that AI could help avoid drug interactions by giving personalized treatments. In a study by Sabah et al., students showed optimism regarding the potential (54% felt it was likely, 37.8% thought it could be possible 25 years from now) [80].

These findings show an understanding among the students of AI's role in precision medicine. In contrast to our results, Jha et al. conducted a study on students and interns at KIST Medical College in Nepal. It was reported that only 24.5% of the participants felt that AI can formulate personalized treatment plans for patients [12]. The contrast might be explained by varying degrees of openness and trust in AI-powered systems.

Our study found that 68% of students agreed that AI can help patients be more informed about their health. Also, 65% agreed that AI can make it easier for patients to access healthcare. Jackson et al. reported similar findings with 59.4% agreeing that AI would help educate patients and 60.9% agreeing that AI would improve access to healthcare [10].

3.4-4 Administrative efficiency and resource management:

Our findings have also shown that 88% of participants believe AI would help in resources and time saving. Additionally, 89% of respondents believed that AI in administrative tasks will reduce healthcare professionals' workloads. Other studies also support the potential. For example, Sabah et al. reported that 74.8% of participants believed AI could help hospitals with planning and human resources. Puchhio et al. reported a 64% agreement rate. Moldt et al. reported 83.3% [68,80,81].

Although we note a difference in rates across the different studies, the findings suggest a general positive perception around AI being time and resources effective. In literature, it is suggested that If work requiring repetitive tasks is delegated to AI, it would reduce the workload on

healthcare workers and would leave them with complex tasks in relation to their patients. As an example, AI can assist ophthalmologists by automating the initial assessment of fundus photographs. This allows doctors to prioritize patients who require urgent attention and designate more time to surgical procedures or patient consultation [69,82].

But as opposed to our findings, a study by Jha et al. found that 89.4% of the students felt that it unlikely that AI assists hospitals in capacity planning and HR management [12].

The source of this divergence might be due to different exposure to AI's current abilities, as well as a more general negative perception of it. A study by Rossi et al. reported that current research on AI's cost-effectiveness remains inconclusive. It does not confirm if specific AI solutions are practical in economic ways. They also suggest better reporting on costs in order to help future research to determine cost-effectiveness [83].

3.4-5 Trust and reliability in AI:

Our study also shows that students are still weary when it comes to complete trust in AI. Only 30% of students agreed that AI could improve patients' trust in medical decisions. Most were uncertain. Similarly, a study by Jackson et al. found that 52.9% of respondents felt that AI applications could damage patients' trust [10]. This might suggest that students are apprehensive about AI's impact. These findings underline the difficulties AI faces in trying to win confidence and acceptance in the medical context.

Many respondents had mixed views on students' trust in AI guidelines based on medical datasets. 35% were positive, and 40% neutral. This suggests a more nuanced opinion than a simple majority or minority vote. Some argue that healthcare needs better software to analyze data. AI solutions are often suggested as the key to exploiting healthcare's vast datasets. Especially since neural networks can be trained to effectively find patterns. However, the diversity in data remains a challenge in standardizing information, as well as insuring its quality and accuracy [84,85].

4. Students' perception on AI's effect on jobs and specialties:

4.1 Students' perception on the future potential of AI in replacing clinical practitioners:

Students' majority agreed that AI can't replace clinical practitioners (83.5%). In accordance with our findings, a study by Pinto Dos et al. found that 61.6% of students disagreed that human physicians could be replaced in the future. Additionally, a study conducted by Jebreen et al. found that 74.2% of the students did not think that doctors would be completely or partially replaced by AI and 68.8% of students believed that AI would optimize the services provided in healthcare. Additionally, Civaner et al. reported that most participants (74.4%) believed AI will help them become better physicians. This might hint that students probably perceive AI as a potential tool for enhancing medical practice rather than replacing it. This comes in accordance with a multinational study that included 63 countries, where 72.2% students viewed AI as a collaborator rather than a rival [11,79,86,87]

4.2 Students' perception on specialties they perceived as replaceable by AI:

Amongst the students who believed that practitioners might be replaced by AI. We noticed that biology and medical non-interventional specialties were the most chosen with rates of 66.7% and 45.1%, respectively. While students were more reserved when it came to AI capabilities replacing medical interventional specialties (9.8%) or surgical specialties (3.9%). Most choices being biology and non-interventional specialties might be explained by students perceiving them as data driven and rule-based, making them a potential target for AI automation. Surgical specialties and specialties with interventional fields are probably perceived as more of a manual skills field, which may seem as more challenging for AI to be involved in.

4.3 Students' perception of AI influence on medical jobs and specialty choices:

Our study indicates that students are apprehensive about the possible AI's effects on their careers. 42% of our students felt that AI will negatively influence job prospects. Other studies report varying concerns about AI's effect on jobs. For instance, Jackson et al. noted that 37.6% of students feared that AI would reduce the need for physicians and their job opportunities. Jha et al. reported a rate of 49.1%. However, a study by Moldt et al. reported that only 16.7% of students feared losing their jobs to AI [10,81,81]. It suggests that while concerns about AI exist, it might not be universally perceived as a threat to professional security.

58% of our students believe that AI's impact on job opportunities would be specialty dependent. 38% believed AI could replace some medical specialties in the future. Our findings align with multiple studies. Jha et al. reported that 65% of students expected AI's effect on some areas of medicine to be greater than others. Tung et Dong reported a rate of 66.2%. Also, 60% of their students expect AI to replace some specialties in their lifetimes. Sit et al. reported that half of their respondents believed some specialties would be fully taken over by AI in their lifetimes. Additionally, a study by R et al. reported an agreement rate over 75% [8,12,63,88].

Our findings suggest that some students fear the obsolescence of some specialties. However, multiple studies argue that rather than physicians becoming redundant, AI might shift their roles. Instead of being mere custodians of information, they might manage it [10]. This model is set to shift towards healthcare professionals evaluating AI results, with a critical lens and combining them with their clinical knowledge and individual patient considerations to arrive at well informed judgments. This transformation underscores their responsibility in overseeing data and guarantees that AI complements personalized care rather than supplant it.

Many students (59%) believe AI will influence their choice of medical specialty. Multiple studies support this sentiment. Jha et al. reported that 37.2% of respondents felt that their specialty choice would be impacted. Jebreen et al. reported a similar view, with a 31.7% agreement rate. Additionally, Jackson et al. reported that 35.1% of students would choose a specialty based on AI usage [10,12,86]. Moreover, several studies show that AI can deter students from radiology careers. For example, Sit et al. found that 49.2% of respondents were less likely to pursue radiology due to AI. B et al. reported that 1 out of 6 students is less likely to choose radiology due to developments in AI. A US-based study found that 23% of students doubt choosing radiology careers for fear it may become outdated [88–90]. Although other studies show a lower rate of negative perceptions, it is still of great significance, since all studies agree that AI is influencing decisions about future medical careers.

The exact extent of AI's influence remains debated. Many experts still maintain that human judgment and expertise will remain essential in healthcare. Some argue that medicine is an

inherently human, vital, and dynamic field. It's unlikely that it will adhere to the linear nature of algorithms. With that being said, these suppositions are still premature. At our current level of AI, AI tools in healthcare are mostly means for assisting physicians and healthcare systems [5,77,91].

Our results demonstrate that students realize the capabilities of AI to change the medical field. However, they still don't know how those changes will fall into place in terms of career security and professional roles. What we know is that students have reported a level of apprehension regarding AI tools leading to a lack of trust. This level of concern can present an obstacle in AI implementation [77]

5. Students' perception of potential AI ethical and legal implications and challenges:

5.1 Students' perception on ethical challenges:

5.1-1 Data security:

The nature of AI working process with its need for data creates privacy concerns regarding the use of sensitive information. The rise of the digital era and the growing reliance on technology, including health-monitoring systems and other remote applications, has heightened the risk of data misuse [92].

There are various ways that AI powered tools can compromise data privacy. For example, tracking patients using mined data for monitoring without consent. Biometric recognition has access to sensitive data, like facial and voice recognition, and iris patterns. The unauthorized usage of this information can compromise anonymity in public spaces [92].

Furthermore, AI-driven prediction and profiling can extend beyond data analysis to categorization of individuals, often without explicit consent. If this feature is used, for example in social scoring, like it was done in China, it can potentially impact patients' access to healthcare services [92]. In our context, it could be misused for indexing people for services such as insurance. Additionally, data breaches and unauthorized access to confidential data, can consequently cause identity theft. In 2018, 2216 data breaches were reported from 65 countries [92,93].

Model privacy is also a concern for AI usage in a clinical context. Algorithm models can be stolen, tampered with, or used to steal data. This calls for protecting both the algorithm integrity, as well as the data it learns from [92].

In our study, 51% of our students believed that the use of AI in storing and accessing clinical history poses a higher risk to patient privacy than traditional means. In a study by Syed et al. 28% believed that with AI violations of professional confidentiality may occur more [94]. We note differing percentages in both studies. However, the findings elude nonetheless to students' concerns regarding privacy when it comes to using AI in healthcare.

In our digital era, privacy issues are unavoidable. AI implementation needs to conform to strict security measures in order to protect sensitive information. Adhesion to privacy preserving techniques such as the use of encryption, controlled access and strict respect of legal regulations like Health Insurance Portability and Accountability Act in the United States (HIPPA) or General data protection regulation in the European Union might allow for a secure use of AI tools. Additionally, because of the growing nature of the AI field, updates and audits on protocols concerning the security of its usage need to be maintained, as well as the continuous training of healthcare workers on data security, both are essential keys to maintaining the safe usage of AI tools.[95–97]

5.1-2 AI safety:

Half of our participants believed that AI in healthcare harms its safety. These findings hint to students' wariness regarding algorithmic inaccuracies and errors in medical decision-making that can lead to poor patient care [98].

Chen et Decary proposed a guide to properly use AI in healthcare. To ensure its safety, we must evaluate its potential hazards. An assessment of errors and consequences is an essential step to develop preventive measures. It's recommended to use dual safety mechanisms, such as clinicians' validations for judgment related decision-making such as diagnosis and treatment. Additionally, the implementation of pilot testing is an important step before using any device to ensure its effectiveness and safety. Continuous monitoring of real-world data is important as

well to ensure that AI systems operate reliably. Furthermore, policies and regulating laws need to be implemented regarding the use of AI devices to ensure privacy, security and ethical use. It is also important to require patients' consent when it comes to the use of their data for functionality improvement [99].

5.1-3 AI and the clinician-patient relationship:

63% of our students believed that AI could compromise the human aspect of medical practice. Additionally, 67 % reported that AI could compromise the clinician-patient relationship. In accordance with our findings, a study by Jackson et al. reported that 69.2% of the students believed that AI could reduce the humanistic aspects of medicine, and 54.5% expressed concern that it might negatively impact patient-physician relationship. Similarly, Syed et al. reported that 50.3% of students felt the same about AI impacting the human part of medicine. In a lower degree, a study by Civaner et al. noted that 45.5% were concerned about AI damaging the fundamental value of trust [10,79,94].

Although we can note varying rates of agreement, the overall perception alludes to students' negative view of AI when it comes to influencing the patient-doctor aspect of medical care. Some argue that AI depersonalizes patient care and that decisions will eventually be fully based on analytics, exempt of human feelings and trust. In a study by Langoni et al. on resistance to medical AI, it reported that people felt that it can't consider the people unique features and characteristics. Additionally, research suggests that AI integration in healthcare is more accepted when it's done in models that preserve the integrity of the interpersonal relationship between patients and physicians [100–103]. Therefore, emphasizing the importance of respecting the integrity of human contact.

5.1-4 AI in our social context:

In our study, 38% believed that implementing AI in healthcare in our social context is possible. This low rate might be due to our students' concern regarding infrastructure and technological barriers. In the official website of Morocco AI, a non-profit educational and research organization, Morocco ranked 79th globally and 3th within Africain the 2023, in terms of data and infrastructure readiness for AI [104].

It is important to note that for AI tools to be generalized, governments will need to allocate resources and investments in order to structure an appropriate IT system all over the country. This might prove a challenge in our context since some primary health centers have not yet adopted electronic tools. Additionally, many factors, including cultural, geographic, and economic difference, can influence individuals' access to AI-driven healthcare, resulting in digital health inequity. In a study by Jha et al. over 70% showed concern over AI raising health equity and new social questions. Their negative perception might also be related to their wariness around social acceptance. Some studies have shown that patients might prefer human interaction over automation, even at the expanse of performance, valuing qualities like gentleness and compassion [12,105–107].

5.1-5 AI and ethics:

78% of our students didn't think that AI applications can respect the ethical part of medical practice. Moreover, 82% of our students agreed that the integration of AI in healthcare would present new ethical considerations. In accordance with our study, Jha et al. reported that almost 90% of their students believed that new ethical issues will be raised with the advancement of AI. Moreover, 87% of the participants in a study by Hadithy et al. shared the same opinion. Busch et al. reported that 69.31 % of their students believed that AI in healthcare will lead to legal and ethical issues [12,62,108]. These findings further support students' growing concern about AI's ethics in healthcare. These ethical dilemmas must be addressed as AI research continues to flourish.

5.2 Liability of AI mistakes: Participant Perspectives:

With AI gaining autonomy, it is important to determine the legal aspects of its inclusion in healthcare. When we asked our respondents about their perspectives concerning liability of AI mistakes, students demonstrated a strong preference (72.6%) for shared responsibility amongst the stakeholders involved in the design, use and implementation of the AI system. While the least popular option was assigning liability purely to the healthcare professional (6.8%). These findings emphasize the perception that errors shouldn't be linked only to practitioners' malpractice because they only represent one of the many actors in the implementation of AI. Errors must be

analyzed to determine healthcare workers participation and determine liability accordingly [109–111].

Algorithm designers and device manufacturers represented 17.4% and 15.5% of the total choices, respectively. These percentages are notably lower than the one on shared responsibility. This might suggest that students believe that while algorithm designers and device fabricants play an important role, they are not independently accountable for AI-related issues. This sentiment aligns with existing literature, where they address that laws governing product liability when it comes to AI are not yet settled. Manufacturers could be held accountable for product errors, from flawed design and manufacturing issues to negligence of warnings disclosure. However, patients would need to prove the direct involvement of the device/algorithm, and that safer alternatives existed. But such claims can be harder to prove with medical AI [98,112].

Legal frameworks must be reviewed in the light of AI integration into healthcare. As much as AI promises great things for healthcare, conventional notions of liability cannot come to terms with its unpredictability. AI neither disposes of free will nor awareness therefore it can't be it held responsible [111,113].

It's very important to explore alternative approaches to avoid potential problems. Effort should be directed into understanding and optimizing AI's role in health care. We also need clear guidelines for developers and health professionals in order to establish safe and effective inclusion. The courts and policymakers must establish laws for liability to share the responsibility equitably among all stakeholders. It will also ensure safe and ethical AI/ML development and integration in healthcare [98,113].

Overall, it is important to update technology and ethics to meet society's changing needs and values. Liability concerns should not hinder the development of AI in healthcare. Reluctance in using innovative technology to reduce errors in healthcare can be in itself malpractice [111,112].

5.3 Perception of Future Challenges of AI in medicine:

What makes AI different from other technological innovations is its inherent capability to auto-improve via deep learning. This difference makes AI deviate from the ethical norms that advanced technology falls under, from data privacy to liability in case of mistakes. If AI tools are to be incorporated in clinical environments, then a legal and regulatory framework is necessary for guaranteeing safe conduct [114,115].

5.3-1 Data security:

We evaluated students' perception regarding AI ethical challenges they perceived as harder to overcome. We noticed that an important portion of students (66.5%) perceive privacy and data security as the most significant challenge. This indicates students concern about how AI systems can manage sensitive data, and their awareness of data security. As we addressed earlier, security threats are a reality that we must continually confront in this evolving digital era. As for any field that deals with data, security measures must be implemented to ensure safe AI usage.

5.3-2 Transparency issues:

Almost half of our students (49%) were concerned about the transparency of AI devices and their ''black box'' nature that usually can't adhere to full transparency of the decision-making process. When it comes to the implementation of AI in the medical field, most healthcare workers are preoccupied with the insurance of AI outputs being accurate and reliable. This concern have consequently led to serious questions around transparency, responsibility and the role of human control [116,117].

Our literature review identified three primary factors concerning the opacity or transparency issue when It comes to AI: the ownership nature of algorithms, which can be addressed through better regulation; the public's limited understanding of programming and algorithmic concepts, which can be addressed through appropriate education; and the inherent complexity of algorithms themselves also known as the black box [111,118,119].

This black box nature of deep learning-based medical AI can be a source of mistrust because the medical field fundamentally requires explainability and logic. The European Institute of

Innovation & Technology recommended that divulging the data source used to create the algorithm's learning input would be a possible answer to establishing transparency. As well as continuous assessment of the quality of data used to train the algorithm as recommended by the department of health and social care. Another point of view has also been argued by Geoff Hinton, a pioneer in DL. In an interview, he stated that laws should not be strict in demanding a full understanding of how AI algorithm's function, with the argument that even people can't fully explain their own decision-making process. However, as we stated earlier, it can't be the case for the medical field because clinician decisions follow a logic, and it is important that clear explanation be given to AI recommendations to reinforce trust [120–123].

5.3-3 Biased decision making:

43.9% of our students cited biased decision-making as a main concern. This puts emphasis on the importance of fairness and equity in healthcare decisions and the distribution of resources. It shows that students are aware of the importance of developing AI algorithms that are fair in order to uphold the ethical responsibility of non-maleficence. The unfairness of biased algorithms can be mitigated by the use of inclusive and varied datasets in training Language modules and AI algorithms, as well as building a foundation of responsible and ethical technology development [111,124]

5.3-4 Patients' trust in AI based tools/ Impact in the patient-physician relationship:

About 33.5% of our students cited patients' trust in AI based tools as a main challenge for AI implementation, and 22.6% were concerned about its impact on the patient-physician relationship. While this may seem like a lower rate compared to those who found data security more challenging, alternatively, it shows that a little over one-third of our students and a little over one-fifth, respectively, believe that AI would irredeemably impact patients' trust and the clinician-patient relationship. Consequently, this might affect their willingness to use AI in their daily practice. Some perceive the integration of medical-based language learning modules as a potential factor of detachment and impersonal care, affecting as a result their trust in medical decisions, treatment adhesion and outcomes. Which brings us to the question concerning the right implementation plan. Jayakumar et al. suggested that LLMS or AI algorithms being supplemen-

tary tool for clinicians rather than a direct replacement is more in line with preserving patients' trust and autonomy [124–126].

We mut say that the prematurity of AI research, and the fact that It's not yet generally used in clinical practice need to be taken into consideration while navigating its ethical challenges. These issues might vary depending on the stages and the implementation plan of AI tools. The objective of addressing ethical issues is to facilitate AI navigation in the medical field, and to address these hurdles with regulation and policies in a mindful way in order to not hinder any possible AI progress [115,127].

6. AI in the medical education:

6.1 AI courses inclusion in the curriculum and its form:

6.1-1 AI courses inclusion in the curriculum:

60.1% of our students agreed with AI inclusion in the curriculum. It goes in line with multiple other studies. For example, Sharma et al. found that 62.7% of medical students believe that AI should be integrated into their curriculum. Other studies have shown similar results, with 67% of respondents in Pucchio et al. AI's study and 93.8% in Civaner et al.'s study agreeing with the inclusion of AI in medical education. Additionally, 81.2% of medical trainees in Jha et al.'s study believe that they should be required to receive training in AI competencies, and 71.1% in Tung et al.'s study believe that teaching in AI will be beneficial for their careers. Overall, there is a growing consensus among medical students that AI is an essential tool that should be integrated into medical education. The Ontario medical students association advocated for the integration of AI education in the medical curriculum in a paper they published, accenting the importance of AI influence in healthcare [8,12,68,79,128,129].

6.1-2 AI courses form of inclusion:

Regarding the preferred modes of AI education delivery among students. Our study reveals that when given a choice, students expressed a strong preference for conferences and seminars (64.2%), closely followed by online learning modules (53.7%). Lectures, however, only represented 29.1% of the total responses. Comparatively, a study conducted in India showed that traditional lectures were also unpopular, with only 12.6% of respondents favoring it. Additionally,

Liu et al. reported that students favored flexible AI in medicine learning opportunities, such as short lectures, electives, Q&A panels, and workshops. These results hint at students' preference for adaptable educational opportunities because they can be both more accepted by learners and easily applied in a demanding curriculum, allowing them to engage voluntarily. Medical students may be inclined to participate in self-learning from extracurricular sources if AI education becomes more accessible through massive open online courses (MOOCS) [61,129–131]

6.2 Students' perception of using chat-bots or LLMs in the medical education:

The integration of large language models (LLMs), like OpenAI's GPT and Google's Gemini, has become a hot topic, especially in education. OpenAI's GPT-4 has even proved its capability of assimilating medical information. When tested on the US Medical Licensing Exam (USMLE), GPT scored over 83% on all steps, outperforming most human test-takers. Additionally, Morocco's educational system is starting to embrace the potential of AI in learning. The country now hosts the first university in Africa to implement AI-powered education "ChatGPT Edu", marking a major step toward academic integration of AI [132,133].

In exploring students' views on using chat-bots in medical education in our study. We noticed the emergence of three principal themes. Some students thought that it might be beneficial to their education. Others advocated for a more cautious approach. It was stated that although these tools can be useful, they must be used thoughtfully: **"I think they can be useful in getting information, but whether the source is reliable or not the person using AI should always check for that unless they make a chatbot dedicated to medical education and has the latest guidelines".**

We also got some disagreements among the students, stating that chatbots are not reliable tools. A student stated, **"I'm against the idea, medical knowledge should be based off on fact-checked resources, not an algorithm that skims through different and potentially unreliable resources and generates combined results that are prone to error".**

This qualitative data shows that students recognize the potential of AI powered educational tools. It is anticipated that in the near future, medical students will have access to ad-

vanced LLMs dedicated to the medical fields. These AI systems promise the creation of adaptive learning content tailored to each student's needs and questions. Unlike traditional static textbooks, this approach offers a personalized and efficient learning experience. Students can find accurate, timely, and relevant information. This lets them explore topics and quickly answer their questions. Additionally, LLMs can also be used as simulated patients via Text-to-Speech technology. Furthermore, chatbots can also be used in clinical reasoning, to analyze and understand the relationships between different concepts[134].

However, our results also note students' wariness regarding the challenges of using LLMS for education. Their integration is argued to present several hurdles. LLMs wide range abilities raise concerns about potential academic misconduct and plagiarism. Also, their predictive nature is said to lead to incorrect or misleading information if the generated text is not critically examined. The ease with which LLMs can generate information might also affect students' motivation to engage their thinking abilities. An overreliance on AI tools could have cognitive long-term consequences. Concerns like privacy and access inequities require careful consideration as well [132].

While it's important to use the best available tools to reach respectable end goals. It is equally important that students are taught how to use these supportive tools in a way that is mindful and ethical.

7. Study forces and limitations:

7.1 Study limitations:

An accurate up-to-date data for the number of medical students in Morocco was not available, therefore the sample size needed for this study was not determined. Additionally, 38.4% of the participants in our study were from the faculty of medicine and pharmacy of Marrakech. It is possible, therefore, that the study's results may not fully represent all Moroccan medical students. Moreover, it should be noted that this research aims to understand the perception of Moroccan medical students toward AI. It does not seek to draw definitive conclusions.

Additionally, students' participation in our study was deliberate and voluntary. We therefore assume that students who felt more engaged with the topic were more likely to complete the questionnaire. On the other hand, students who were busier were more likely to skip filling out the survey. We also assume that students less interested in the topic felt less motivated to complete the questionnaire.

7.2 Study forces:

A self-reported, online questionnaire has the advantage of being easier to fill out. It also does not influence responses, unlike an examiner-administered one. Additionally, it has the advantage of being anonymous encouraging honest answers.

The survey combines close-ended and open-ended questions to yield both quantitative and qualitative data relating to students' awareness levels and views, along with students' individual concerns, opinions, and recommendations about AI. This combination gives the findings additional depth.

This study gives an up-to-date snapshot of the attitudes that future healthcare professionals hold towards AI at a time when the rapid evolution of AI technologies in the field of health is occurring. By considering both the technical and ethical aspects of AI in healthcare, the study offers a general view ensuring reasonable knowledge of AI's potentialities and challenges. The findings will be helpful in educating healthcare students for appropriate acceptance of AI in practice. This fills an identified gap in the literature as it addresses a relatively narrow area of research that opens a discussion about students' attitudes toward AI applications in healthcare. Furthermore, this study is among early efforts in Morocco to understand the perception of medical students regarding AI in the context of medicine.

Conclusion

The investigation of medical students' attitudes and perceptions toward the integration of AI led to the conclusion that students have a notable knowledge gap about AI, both in general knowledge and its healthcare applications.

While students show openness and optimism about AI's potential to enhance medical practices. We can also note a level of apprehension regarding its impact on job security. Many students revealed a negative perception of AI's influence on job opportunities and specialty choices. Ethical and legal issues it introduces were also a source of notable concern, such as privacy issues, biased decision making, transparency and responsibility. Additionally, there are fears that the adoption of AI would disrupt traditional roles in healthcare as well as affect the patient-and-physician relationship and trust.

Interestingly, notwithstanding such concerns, students were willing to embrace AI within their medical curriculum. This stresses an openness to adapt change and evolving technologies in a manner that helps their future practice, rather than opposition towards change for fear of displacement. By integrating AI into the curriculum, we can ensure that future physicians are up to date with healthcare information technology while still preserving the core principles of patient-centered care.

Moreover, promoting a critical and analytical perspective on AI is equally essential. Media often creates sensational allegations about AI. This can participate in shaping students' misconceptions about its abilities/effects. It is important to teach medical students to approach presumptions around AI in medicine with a critical mindset, rather than accepting them at face value from media and online sources. Building skills via education and having a basic understanding of AI is an essential step to separate reliable information from hype.

Recommandations

Recommendations:

1. Addressing skepticism and concerns:
    - Organize forums and activities for professionals to discuss AI issues with students. It could provide a platform for students to ask questions, share their concerns so they may develop a balanced opinion of AI in medicine.
    - Open discussions around the ethical implications of AI. Addressing these issues will reduce uncertainty and help students understand AI's role within a regulated and ethical framework.
2. Curriculum enhancement:
    - Include AI-related content in the form of courses in the curriculum especially in a voluntary forum. This could involve topics in relation to medical ethics, health informatics, etc. The Introduction of AI will ensure students awareness of its benefits and challenges in the medical field.
    - The development of interdisciplinary learning between medical schools and computer science departments. This collaboration exposes medical students to the technological basis underlying these tools to bridge the gap between healthcare and technology.
    - Faculty should be encouraged to explore the use of AI in their teaching practices. AI-driven simulations, diagnostic tools, and virtual patient platforms could be used in educational forms.
3. Further research directions:
    - **Longitudinal studies**: Future research such as longitudinal studies are recommended to track how students' perceptions of AI evolve with the growth in AI. This would provide valuable insight into how exposure to AI in coursework and clinical practice influences their views and understanding of the technology.
    - **In-Depth qualitative research**: Further qualitative cases should be presented where interviews or focus groups will seek to understand students' feelings concerning AI use.

4. AI in Healthcare growth:

- Encouraging students to engage in research projects that focus on AI applications in healthcare is another recommendation. These research opportunities would deepen their understanding of AI's potential and limitations, while also contributing to the growing body of knowledge in the field.

ABSTRACT

Abstract

INTRODUCTION: AI in medicine (AIM) has recently shown growth in many medical specialties, including biology, pathology, and radiology. Medical students are regarded as future caregivers and one of the determinants of the effectiveness of integrating AI technology into the healthcare system [8]. Our study's main objective is to explore students' level of AI knowledge in healthcare. Additionally, it intends to evaluate their perception toward AI's potential impact on clinical roles, job allocation, ethical and legal challenges as well as on incorporating AI training into the medical curriculum.

PARTICIPANTS AND METHODS: This observational cross-sectional study was conducted over a four-month period from June to September 2024, targeting Moroccan medical students across all study years. Participants were recruited from nine Moroccan public medical faculties to complete a self-administered online survey. A voluntary response sampling method was employed. We developed the survey content from existing literature and pilot-tested it on ten students for validity. Data were analyzed using SPSS and Excel for descriptive statistics and bivariate analysis, with informed consent secured from all participants.

RESULTS: In total 310 students participated. The participants had a sex ratio of 0.65 with the ages 24, 25 as the most representative in our sample. Most respondents were from FMPM representing 38.4% of the respondents and 7th year medical students accounted for 20%. 15.6% of our students noted adequate or high familiarity with AI in the medical context. 45.2% were open to using AI diagnostic tools and 43.2% were unsure. The majority agreed that AI cannot replace clinical practitioners (84%). However, most students saw AI's potential in healthcare such as enhancing medicine (84%), facilitate access to knowledge (91%), and make personalized treatments (76%) and its potential to also help with patients' health education (68%) and hospital management (89% agreed AI can help in administrative tasks). 42% of our students felt that AI will negatively influence job prospects and 59% believe AI will influence their choice of medical specialty. 82% of our students felt that AI would present new ethical challenges. Additionally, 63% of them believed that AI could compromise the human aspect of medical practice. Students felt that the most significant challenge to overcome is privacy and data security with a rate of 66.5%. When it came to AI inclusion in the curriculum, students noted an agreement rate of 60.1%.

CONCLUSION: We can conclude the existence of a knowledge gap about the subject of AI, both generally concerning knowledge around AI and specifically for its healthcare applications.

While students show openness and optimism about AI's potential to enhance medical practice. We can also note a level of apprehension regarding its impact on job security. Many students were also warry regarding ethical and legal challenges. However, despite these concerns, students expressed a willingness to incorporate AI within their medical curriculum.

Résumé

INTRODUCTION : De nos jours, l'intelligence artificielle en médecine a beaucoup progressé dans plusieurs champs médicaux. Les étudiants en médecine sont considérés comme les futurs professionnels de la santé et l'un des facteurs déterminants de l'efficacité de l'intégration de la technologie de l'IA dans le système de santé. Notre étude a donc pour objectif d'évaluer les connaissances des étudiants en médecine concernant l'IA en santé. Elle recherchera aussi leur point de vue concernant le potentiel impact de l'IA sur : les fonctions cliniques, la répartition des tâches, les problèmes éthiques et juridiques ainsi que sur l'intégration de la formation à l'IA à leur parcours médical.

PARTICIPANT ET METHODES : Cette étude observationnelle transversale s'est déroulée sur une période de quatre mois, de juin à septembre 2024, et a ciblé des étudiants en médecine marocains de toutes les années d'études, y compris ceux en instance de thèse. Les participants ont été recrutés dans les neuf facultés de médecine publiques marocaines et ont répondu à un questionnaire en ligne auto-administré. Un échantillonnage à participation volontaire a été utilisé. Le contenu du questionnaire a été élaboré à partir de la littérature existante et testé en amont sur dix étudiants pour en vérifier la validité. Les données ont été analysées avec SPSS et Excel pour les statistiques descriptives et l'analyse bivariée. Le consentement éclairé a été recueilli auprès de tous les participants.

RESULTAT : Au total, 310 étudiants ont participé à l'étude. Les participants avaient un sexe-ratio de 0,65. Les âges de 24 et 25 ans étant les plus représentés dans notre échantillon. La majorité des répondants provenaient de la FMPM avec un taux de réponse de 38.4%. Les étudiants en 7e année représentaient 20 %. Parmi nos répondeurs, 15,6 % ont indiqué avoir une familiarité adéquate ou élevée avec l'IA dans le domaine médical. 45,2 % étaient favorables à l'utilisation d'outils de diagnostic basés sur l'IA, tandis que 43,2% étaient incertains. La majorité a convenu que l'IA ne peut pas remplacer les praticiens (84 %). Cependant, la plupart des étudiants voient le potentiel de l'IA dans la santé, comme l'amélioration du système de santé (84 %), la facilitation de l'accès aux connaissances (91 %), et la personnalisation des traitements (76 %), ainsi que son potentiel pour l'éducation des patients (68 %) et la gestion hospitalière (89 % ont estimé que l'IA peut aider dans les tâches administratives). Par ailleurs, 42 % des étudiants pensent que l'IA influencera négativement les perspectives d'emploi et 59 % estiment qu'elle influencera leur choix de spécialité médicale. 82 % de nos étudiants estiment que l'IA soulèvera

de nouveaux défis éthiques, tandis que 63 % d'entre eux pensent qu'elle pourrait compromettre l'aspect humain de la pratique médicale. Enfin, 66.7 % perçoivent la confidentialité et la sécurité des données comme le principal défi à surmonter. Quant à l'inclusion de l'IA dans le programme d'études, elle a reçu un taux d'accord de 60.1 %.

CONCLUSION : Nous pouvons conclure à l'existence d'un manque de connaissances sur le sujet de l'IA. Cela concerne à la fois ses applications dans la santé ainsi que le niveau de connaissances générales des étudiants sur le sujet. Bien que les étudiants montrent de l'optimisme quant au potentiel de l'IA pour améliorer les pratiques médicales, un certain niveau d'appréhension concernant son impact sur la sécurité de l'emploi est également noté. Beaucoup d'étudiants se montrent également prudents face aux défis éthiques et juridiques posés par l'IA. Cependant, malgré ces préoccupations, les étudiants expriment une volonté d'intégrer l'IA dans leur cursus médical.

ملخص

مقدمة

يشهد الذكاء الاصطناعي في المجال الطبي حاليا تطورًا كبيرًا في عدة ميادين. باعتبار طلاب الطب مهني الصحة في المستقبل وأحد العوامل الحاسمة لفعالية دمج تقنيات الذكاء الاصطناعي في النظام الصحي، تهدف دراستنا إلى تقييم معرفتهم بهته التقنية في المجال الصحي. كما تسعى إلى استكشاف وجهات نظرهم حول التأثير المحتمل للذكاء الاصطناعي على: الوظائف السريرية، توزيع المهام، القضايا الأخلاقية والقانونية، بالإضافة إلى استكشاف تصورهم عن إدماج التدريب على الذكاء الاصطناعي في مسارهم التعليمي الطبي.

المشاركون والمنهجية:

أُجريت هذه الدراسة الرصدية المقطعية على مدى أربعة أشهر، من يونيو إلى شتنبر 2024، واستهدفت طلاب الطب المغاربة من جميع السنوات الدراسية، بما في ذلك منهم في مرحلة إعداد الأطروحة. شارك طلاب الطب من تسع كليات عمومية في المغرب من خلال استبيان إلكتروني ذاتي الإكمال. اعتمدنا في طريقة اختيار العينة على المشاركة التطوعية. تم إعداد محتوى الاستبيان بناءً على الأدبيات الموجودة، واختُبر مسبقًا على عشرات الطلاب للتحقق من صلاحيته. تم تحليل البيانات باستخدام برنامجي SPSS و Excelللإحصاءات الوصفية وتحليل التباين الثنائي، وتم الحصول على موافقة جميع المشاركين.

النتائج:

شارك في الدراسة ما مجموعه 310 طالب. حيث بلغت نسبة الاناث المشاركين60.6% وكانت الفئة العمرية 24-25 عامًا الأكثر تمثيلًا في العينة. تلقينا غالبية الاجابات من كلية الطب بمراكش بنسبة 38.4%، ومثل طلبة السنة السابعة نسبة 20%. أشار 15.6% من المستجيبين إلى امتلاكهم معرفة كافية أو مرتفعة بالذكاء الاصطناعي في المجال الطبي. أيد 45.2% استخدام أدوات التشخيص القائمة على الذكاء الاصطناعي، بينما أعرب 43.2% عن ترددهم. كما أجمعت الأغلبية (84%) على أن الذكاء الاصطناعي لا يمكنه استبدال الأطباء.

على الرغم من ذلك أعرب معظم الطلاب عن إيمانهم بإمكانيات الذكاء الاصطناعي في تحسين نظام الرعاية الصحية (84%)، وتسهيل الوصول إلى المعلومة (91%)، وتخصيص العلاجات (76%)، فضلًا عن دوره المحتمل في تثقيف المرضى (68%) وإدارة المستشفيات (89% اعتبروا أن الذكاء الاصطناعي يمكن أن يساعد في المهام الإدارية).

على صعيد آخر، يعتقد 42% من الطلاب أن الذكاء الاصطناعي سيؤثر سلبًا على فرص التوظيف، و59% يرون أنه سيؤثر على اختيارهم لتخصص الطبي. كما يعتقد 82% من الطلاب أن الذكاء الاصطناعي سيطرح تحديات أخلاقية جديدة، بينما يرى 63% أنه قد يهدد الجانب الإنساني للممارسة الطبية. أخيرًا، اعتبر 66.5% من الطلاب أن الخصوصية وأمن البيانات من التحديات الرئيسية التي وجب التغلب عليها. وحظي إدماج الذكاء الاصطناعي في المناهج الدراسية بتأييد 60.1% من المشاركين.

الخلاصة:

نستنتج وجود نقص في المعرفة بموضوع الذكاء الاصطناعي، سواء من حيث تطبيقاته في الصحة أو مستوى المعرفة العامة للطلاب حول الموضوع. على الرغم من أن الطلاب يعرضون تفاؤلًا بشأن قدرة الذكاء الاصطناعي على تحسين الممارسات الطبية، إلا أن هناك مستوى من القلق حول تأثيره على استقرار الوظائف. كما أن العديد من الطلاب يتعاملون بحذر مع التحديات الأخلاقية والقانونية التي يطرحها الذكاء الاصطناعي. على الرغم من هذه المخاوف، عبر الطلاب عن رغبتهم في إدماج الذكاء الاصطناعي في مناهجهم الطبية.

Appendices:

Survey

CONSENT SECTION

I. Students Profile:

1. How old are you:
2. What's your gender
    - Male
    - Female
3. What's your medical faculty:
    - Faculty of Medicine and Pharmacy of Marrakech (FMPM)
    - Faculty of Medicine and Pharmacy of Agadir (FMPA)
    - Faculty of Medicine and Pharmacy of Rabat (FMPR)
    - Faculty of Medicine and Pharmacy of Tangier (FMPT)
    - Faculty of Medicine and Pharmacy of Casablanca (FMPC)
    - Faculty of Medicine and Pharmacy of Fez (FMPF)
    - Faculty of Medicine and Pharmacy of Oujda (FMPO).
    - Other:
4. What's your level of studies:
    - 1st year medical student.
    - 2nd year medical student.
    - 3rd year medical student.
    - 4th year medical student.
    - 5th year medical student.

- 6th year medical student.
- 7th year medical student
- Thesis awaiting status.

II. General awareness:

1. Artificial intelligence (AI) can be defined as the capacity of machines to imitate or replicate human behaviors and cognitive abilities. Do you agree with this definition?
   - Yes
   - No
2. If you disagree with the definition, what would you define Artificial intelligence as? (Open question)
3. On a scale from 1 to 5, how would you rate your level of knowledge about the concept of artificial intelligence ?
   - 1=No knowledge
   - 2=Minimal knowledge
   - 3=Basic knowledge
   - 4=Adequate knowledge
   - 5=Extensive Knowledge
4. On a scale from 1 to 5, how familiar are you with the applications of Artificial intelligence in healthcare?
   - 1= Not familiar at all
   - 2= Slightly familiar
   - 3= Somewhat familiar
   - 4=Adequately familiar
   - 5= Extremely familiar

III. The application of artificial intelligence in the medical field:

1. Would you be open to using AI diagnostic tools?

- Yes
- Maybe
- No

2. Which of the following tasks do you believe can be delegated to AI?
   - History taking
   - Health files recording
   - Diagnosis and medical decision
   - Medical prescription
   - Patient monitoring
   - No task should be delegated
3. Which of the following implementation plans do you believe would be the most suitable regarding the use of AI?
   - AI can assist in the decision making but it is to the clinician to make the final decision and file the health records
   - AI can assist in the decision making and file the health records, but the final decision is to the clinician
   - The whole process should be automated, AI collects relevant information directly from patients using sensors, makes the final decision and files the record without any input from clinicians
   - None of the above: clinician makes the decision and record health records manually
4. On a scale from 1 to 5, please note to what extent do you agree with the following statements:
   - AI has the potential to enhance the medical profession in general.
   - AI tools and medical chatbots can make medical knowledge and information access easier for clinicians.
   - AI can help physicians make more accurate medical decisions.
   - AI can help avoid drug interactions by giving personalized treatments.
   - AI can reduce the rate of medical errors in healthcare.

- AI can make it easier for patients to be more informed about their health.
- AI can make patients' access to healthcare easier.
- The use of AI will improve patients' trust in medical decisions.
- AI can exceed human achievements in many medical areas
- You would trust the guidelines established by AI through learning from medical datasets.
- The use of AI will help in resources and time saving.
- AI in administrative tasks will reduce healthcare professionals' workloads.
- Integrating AI as a diagnostic tool can minimize the inadequacy between the demand in medical care and the disproportionate number of clinicians.

IV. The influence of AI on job opportunities and the choice of specialty in the medical field:

1. Do you believe AI might be able to replace clinical practitioners in the future?
   - Yes
   - No
   - Other:
2. If you indicated an agreement in your previous answer, which type of specialties do you believe might be replaceable by AI in the future?
   - Surgical specialties
   - Medical non-interventional specialties
   - Medical interventional specialties
   - Biology
   - AI is capable of replacing all practitioners in the future
3. On a scale from 1 to 5, please note to what extent do you agree with the following statements: on a 5-point Likert scale

- AI will negatively influence healthcare job prospects in the future
- AI in healthcare would affect jobs differently by specialty
- The use of AI in healthcare means the end to some clinical professions in the future (e.g. radiology, histopathology, dermatology…).
- The choice of specialty will be influenced by the number of fields that implement/use AI.

V. The ethical implications and challenges of AI:

1. On a scale from 1 to 5, please note to what extent do you agree with the following statements
   - AI integrating in healthcare compromises its safety.
   - AI can compromise the human aspect of medical practice.
   - AI can compromise the clinician-patient relationship.
   - Implementing AI in healthcare in our social context is possible.
   - AI applications can respect the ethical part of medical practice.
   - The integrating of AI in healthcare could present new ethical considerations.
   - The use of AI in storing and accessing clinical history poses a higher risk to patient privacy compared to traditional records
2. Liability of AI mistakes should fall on:
   - The hospital
   - The healthcare professional
   - The device manufacturers
   - The algorithm designers
   - All groups involved in the design, use and implementation of the AI system should have a joined responsibility
3. What future challenges do you think would be harder to overcome with the use of AI in medicine?
   - privacy concerns and data security

- Transparency issues
- Biased decision making
- Patients' confidence in AI devices
- Liability implications
- Impact on the patient-physician relationship

4. What legal or ethical aspects do you suggest should be taken into consideration before integrating AI in the medical practice? (open question)

VI. AI in the medical education:

1. On a scale from 1 to 5, to what extent do you agree that AI courses should be included in the curriculum (e.g. AI basics, ethical considerations, practical application…)
2. If you indicated a disagreement or strong disagreement in your previous answer, could you elaborate on the reasons behind your choice? (open question)
3. If you indicated agreement, strong agreement or neutral in your previous answer, when do you believe is the right time to include Ai education in the medical curriculum:
   - Early in medical education
   - Later in medical education
   - Not sure
   - Other
4. In what form should Ai education be included?
   - Lectures
   - Conferences and seminars
   - Online learning modules
   - Other
5. What other suggested AI-related topics do you believe should be part of the medical curriculum? (open question)
6. What do you think about the use of chat-bots or LLMs in medical education? (open question)

Questionnaire français :

SECTION DE CONSENTEMENT

1. Quel est votre âge ?
2. Etes-vous ?
    - Femme
    - Homme
3. Quelle est votre faculté de médecine ?
    - Faculté de médecine et de pharmacie de Marrakech (FMPM)
    - Faculté de médecine et de pharmacie d'Agadir (FMPA)
    - Faculté de médecine et de pharmacie de Rabat (FMPR)
    - Faculté de médecine et de pharmacie de Tanger (FMPT)
    - Faculté de médecine et de pharmacie de Casablanca (FMPC)
    - Faculté de médecine et de pharmacie de fez (FMPF)
    - Faculté de médecine et de pharmacie de Oujda (FMPO)
    - Autres :
4. Quel est votre niveau d'études en médecine ?
    - 1ère année
    - 2ème année
    - 3ème année
    - 4ème année
    - 5ème année
    - 6ème année
    - 7ème année
    - En instance de thèse

I. Connaissances générales:

1. L'intelligence artificielle peut être définie comme étant la capacité des machines à mimer le comportement et les capacités cognitives humaines. Etes-vous d'accord avec cette définition ?
   - Oui
   - Non
2. Si vous n'êtes pas d'accord avec cette définition, comment définissez-vous l'intelligence artificielle ? (Question ouverte)
3. Sur une échelle de 1 à 5, comment évaluez-vous vos connaissances sur l'intelligence artificielle ?
   - 1 = Aucune connaissance
   - 2 = Connaissance minimale
   - 3 = Connaissance de base
   - 4 = Connaissance adéquate
   - 5 = Connaissance approfondie
4. Sur une échelle de 1 à 5, comment évaluez-vous votre niveau de familiarité avec les domaines d'application de l'intelligence artificielle dans le système de santé ?
   - 1 = Pas du tout familier
   - 2 = Légèrement familier
   - 3 = Assez familier
   - 4 = Adéquatement familier
   - 5 = Extrêmement familier

II. L'application de l'intelligence artificielle dans le domaine médical :

1. Etes-vous ouvert à l'utilisation de l'intelligence artificielle comme outil de diagnostic en médecine ?
   - Oui
   - Non
   - Peut-être

2. A votre avis, laquelle ou lesquelles des tâches suivantes peuvent être déléguées à un logiciel d'intelligence artificielle ?
    - La prise d'historique
    - L'enregistrement des dossiers médicaux
    - Le diagnostic et la décision médicale
    - La prescription médicale
    - Le monitoring des patients
    - Aucune tâche ne doit être déléguée
3. Lequel des modes de mise en œuvre suivants pensez-vous être le plus convenable par rapport à l'utilisation de l'intelligence artificielle dans le domaine médicale ?
    - L'intelligence artificielle peut assister aux décisions médicales mais c'est au praticien de prendre la décision finale et de remplir les dossiers médicaux.
    - L'intelligence artificielle peut assister aux décisions médicales ainsi que remplir les dossiers médicaux mais c'est au praticien de prendre la décision finale.
    - Le processus en totalité doit être automatisé, l'intelligence artificielle fait la collecte des informations directement auprès des patients, prend la décision finale et remplit les dossiers médicaux.
    - Aucune des options ci-dessus : c'est au clinicien de prendre la décision et de remplir les dossiers médicaux.
4. Sur une échelle de 1 à 5, veuillez indiquer votre degré d'accord avec les propositions suivantes :
    - L'intelligence artificielle est capable d'améliorer le système de santé en général.
    - Les outils IA et les chatbots médicales sont capables de faciliter l'accès des cliniciens aux connaissances et informations médicales.
    - L'intelligence artificielle aidera le clinicien à prendre des décisions médicales plus précises.
    - IA est capable d'éviter les interactions médicamenteuses par ses suggestions de traitement personnalisées.

- L'intelligence artificielle est capable de réduire le taux de fautes médicales dans le domaine médical.
- L'IA aidera les patients à être plus informés sur leur santé.
- L'IA facilitera l'accès aux prestations de santé.
- L'utilisation de l'IA optimisera la confiance des patients par rapport aux décisions médicales.
- L'IA dépassera l'accomplissement des humains dans plusieurs domaines de santé.
- Vous ferez confiance aux nouvelles recommandations générées par l'IA à travers les données médicales.
- L'IA est capable de réduire la charge du temps et des ressources.
- L'application de l'IA dans les tâches administratives réduira la charge de travail des cliniciens.
- L'intégration de l'IA est capable de minimiser l'inégalité entre les demandes de prestations de soins et le nombre disproportionné des cliniciens

III. L'influence de l'intelligence artificielle sur les opportunités de travail et le choix de spécialité dans le domaine médical :

1. Pensez-vous que l'intelligence artificielle pourra remplacer un jour les professionnels de santé ?
   - Oui
   - Non
   - Autre
2. Si vous approuvez un accord par rapport à la question précédente, à votre avis, quel type de spécialités pourrait être remplacées par l'intelligence artificielle au futur ?
   - Les spécialités chirurgicales.
   - Les spécialités médicales non interventionnelles.
   - Les spécialités médicales interventionnelles.
   - Les spécialités biologiques.

- L'IA est capable de remplacer toutes les spécialités au futur.

3. Veuillez indiquer votre degré d'accord avec les propositions suivantes :
   - L'intelligence artificielle aura une influence négative sur les opportunités de travail disponible au futur dans le domaine de santé.
   - L'intégration de l'IA dans le domaine de la santé pourrait impacter les emplois de manière variée selon les spécialités médicales
   - L'implémentation de l'intelligence artificielle dans le système de santé mettra fin à certaines spécialités au futur (e.g radiologie, histopathologie, dermatologie…).
   - Le choix de spécialités sera affecté par le nombre de domaines appliquant l'intelligence artificielle.

IV. Les implications éthiques et les défis de l'intelligence artificielle :

1. Veuillez indiquer votre degré d'accord avec les propositions suivantes :
   - L'intégration de l'intelligence artificielle dans le domaine de santé compromet sa sécurité.
   - L'intelligence artificielle compromet l'aspect humain de la pratique médicale.
   - L'intelligence artificielle compromet la relation clinicien-malade.
   - L'implémentation de l'intelligence artificielle dans notre contexte sociale est possible.
   - L'intelligence artificielle est capable de respecter l'aspect éthique de la médecine.
   - L'ère de l'intelligence artificielle va engendrer de nouveaux défis éthiques.
   - L'utilisation de l'intelligence artificielle pour le stockage et l'accès aux dossiers médicaux des patients peut compromettre leurs informations personnelles plus que l'enregistrement traditionnel des informations.
2. A votre avis, les failles de l'intelligence médicale doivent être sous la responsabilité de :
   - L'hôpital.
   - Le professionnel de santé.
   - Le fabricant de l'appareil.
   - Le designer de l'algorithme.

- La responsabilité doit être jointe entre toutes les personnes impliquées dans la fabrication, l'utilisation et l'implémentation du système.

3. A votre avis, quel(s) futur(s)défi(s) de l'utilisation de l'intelligence artificielle en médecine serai(en)t le plus difficile à résoudre/ dépasser
   - La sécurité des données confidentielles et les informations personnelles
   - Les défis de transparence
   - Les décisions biaisées algorithme dépendante.
   - Confiance des patients dans les dispositifs d'IA
   - Implications en matière de responsabilité
   - Impact sur la relation patient-médecin
4. A votre avis, quels sont les aspects légaux ou éthiques à prendre en considération avant l'intégration de l'intelligence artificielle dans la pratique médicale ? (Question ouverte)

V. L'intelligence artificielle et l'éducation médicale :

1. Sur une échelle de 1 à 5, notez votre niveau d'accord sur l'inclusion des cours en rapport avec l'intelligence artificielle dans le curriculum médical (les bases de l'intelligence artificielle, les considérations éthiques, les applications pratiques ...)
2. Si vous avez noté un désaccord sur la question précédente, pouvez-vous élaborer sur la raison de votre choix ?
3. Si vous avez noté un accord/vous étiez neutre sur la question précédente, à votre avis, quel est le bon moment pour l'inclusion des cours en rapport avec l'intelligence artificielle dans le curriculum médical ?
4. A votre avis, les cours en rapport avec l'intelligence artificielle doivent être inclus sous quelle forme :
   - Cours magistraux
   - Conférence et séminaire
   - Des cours en ligne.
   - Autres :

5. Quelles sont vos suggestions concernant les sujets en rapport avec l'IA qu'on peut intégrer dans le curriculum médical ?
    - Au début des études médicales
    - Plus tard dans les études médicales
    - Je ne suis pas sûr(e)
    - Autres :
6. Quel est votre avis par rapport à l'utilisation des Chatbots ou assistants virtuels et LLMs dans l'éducation médicale ? (Question ouverte)

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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 باذلة وسْعِي في انقاذها مِن الهَلاكِ والمرَضِ والألَم والقَلَق.

وأن أحفَظَ لِلنَاسِ كرَامَتهُم، وأسْتر عَوْرَتهُم، وأكتمَ سِرَّهُمْ.

وأن أكونَ عَلى الدوَام من وسائِل رحمة الله، باذلة 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 أختا لِكُلِّ زَميلٍ في المِهنَةِ الطِّبّيَة مُتعَاونِينَ عَلى البرّ والتقوى.

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

والله على ما أقول شهيد

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السنة 2024 الاطروحة رقم :453

استكشاف تصور الطلاب حول الذكاء الاصطناعي في المجال الطبي.

الأطروحة

قدمت ونوقشت علانية يوم 2024/12/02

من طرف

الآنسة شيماء أعرگوب

المزدادة في 01/06/1999 بمراكش

لنيل شهادة الدكتوراه في الطب

الكلمات المفتاحية

طلاب الطب – التصور – الذكاء الاصطناعي – المجال الطبي

اللجنة

السيد	**م.أمين** أستاذ في علم الأوبئة	**الرئيس**
السيد	**ت.أبو الحسن** أستاذ في التخدير والإنعاش	**المشرف**
السيد	**هـ.النجمي** أستاذ في الإنعاش الطبي.	**الحكام**
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السيدة	**ح. رايس** أستاذة التشريح المرضي.	