RESEARCH ARTICLE

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# Artificial Intelligence Readiness Status of Medical Faculty Students

**ABSTRACT**

**Objective:** This research aims to examine the knowledge level and awareness of Faculty of Medicine students about medical artificial intelligence technologies.

**Materials and Methods:** In this study involving students studying at Medical Faculties in Turkey, descriptive questionnaire, and the Medical Artificial Intelligence Readiness Scale for Medical Students (MAIRS-MS) were applied.

**Results:** MAIRS-MS score distributions were lower for students who thought that the use of artificial intelligence in the field of health conflicted with their professional knowledge ($p$=0.001), future goals ($p$<0.001), and would create negativities if not used correctly ($p$=0.006). It was found that the MAIRS-MS score distributions of students who think that artificial intelligence technologies will contribute to the development of the profession ($p$=0.003), and reduce the workload ($p$<0.001), who can distinguish under which conditions they will use artificial intelligence or not ($p$<0.001), and who think that they have enough knowledge to make the necessary explanation to patients who have concerns about artificial intelligence ($p$<0.001), have higher MAIRS-MS score distributions. When the students' follow-up of current information about artificial intelligence technologies in health was examined, it was found that the ethics and ability sub-dimension score distributions were similar ($p$=0.771; $p$=0.069), while the cognition and vision sub-dimension score distributions differed ($p$<0.001; $p$=0.014). When the situation of distinguishing under what conditions to use or not to use artificial intelligence was examined, it was found that the ethics sub-dimension score distributions were similar ($p$=0.088), while the cognition, vision and ability sub-dimension score distributions differed ($p$<0.001; $p$=0.003; $p$=0.001). When the situations of thinking that artificial intelligence training would contribute to the profession were evaluated, it was found that the cognition sub-dimension score means were similar ($p$=0.340), and when the use of artificial intelligence in the field of health conflicted with professional knowledge, the vision sub-dimension score distributions were found to be similar ($p$=0.112).

**Conclusions:** It is seen that the students' awareness level about medical artificial intelligence is high, and they have the ability to use artificial intelligence technologies.

**Keywords:** Artificial intelligence, Artificial Intelligence Applications in Medicine, Education, MAIRS-MS, Technology.

# Tıp Fakültesi Öğrencilerinin Yapay Zekâ Hazırbulunuşluk Durumları

**ÖZET**

**Amaç:** Bu araştırmada Tıp Fakültesi öğrencilerinin tıbbi yapay zekâ teknolojileri hakkındaki bilgi düzeyleri ve farkındalıklarının incelenmesi amaçlanmıştır.

**Gereç ve Yöntem:** Türkiye'deki Tıp Fakültelerinde öğrenim gören öğrencilerin katıldığı bu çalışmada, tanımlayıcı bir anket ve Tıp Fakültesi öğrencileri için Tıbbi Yapay Zekâ Hazır Bulunuşluk ölçeği (Medical Artificial Intelligence Readiness Scale for Medical Students-MAIRS-MS) uygulanmıştır.

**Bulgular:** Yapay zekanın sağlık alanında kullanılmasının mesleki bilgi ($p$=0.001), gelecek hedefleri ile çeliştiğini ($p$<0.001), doğru kullanılmaması halinde olumsuzluklar yaratacağını ($p$=0.006) düşünen öğrencilerin MAIRS-MS puan dağılımları daha düşük olmasına rağmen yapay zekâ teknolojilerinin mesleğin gelişmesinde katkısı olacağını ($p$=0.003), iş yükünü azaltacağını ($p$<0.001) düşünen, yapay zekayı hangi koşullar altında kullanıp kullanmayacağını ayırt edebilen ($p$<0.001), yapay zekâ konusunda endişeleri olan hastalara gerekli açıklamayı yapabilecek kadar bilgisi olduğunu ($p$<0.001) düşünen öğrencilerin, MAIRS-MS puan dağılımları daha yüksek olduğu bulunmuştur. Öğrencilerin sağlıkta yapay zekâ teknolojileri ile ilgili güncel bilgileri takip etme durumu incelendiğinde, etik ve beceri alt boyut puan dağılımlarının benzer olduğu ($p$=0.771; $p$=0.069), bilişsel ve öngörü alt boyut puan dağılımlarının farklılık gösterdiği bulunmuştur ($p$<0.001; $p$=0.014). Yapay zekayı hangi koşullar altında kullanıp kullanmayacağını ayırt etme durumu incelendiğinde, etik alt boyut puan dağılımlarının benzer olduğu ($p$=0.088), bilişsel, öngörü ve beceri alt boyut puan dağılımlarının farklılık gösterdiği bulunmuştur ($p$<0.001; $p$=0.003; $p$=0.001). Yapay zekâ eğitiminin mesleğe katkı sağlayacağını düşünme durumları değerlendirildiğinde bilişsel alt boyut puan ortalamalarının benzer olduğu ($p$=0.340), yapay zekanın sağlık alanında kullanılması mesleki bilgi ile çelişme durumu incelendiğinde, öngörü alt boyut puan dağılımlarının benzer olduğu bulunmuştur ($p$=0.112).

**Sonuç:** Öğrencilerin tıbbi yapay zekâ konusundaki farkındalık düzeylerinin yüksek olduğu ve yapay zekâ teknolojilerini kullanma becerilerine sahip oldukları görülmüştür.

**Anahtar Kelimeler:** Yapay Zekâ, Tıpta Yapay Zekâ Uygulamaları, Eğitim, MAIRS-MS, Teknoloji.

## INTRODUCTION

Artificial intelligence refers to systems or machines that imitate human intelligence to perform tasks and gradually improve themselves with the information they collect. Even though we are not generally aware of it, it has become an important part of almost all our daily lives. It is also a fact that there are very few people knowledgeable about the applications and concepts behind these technologies. It is anticipated that these technologies can facilitate complex processes and important repetitive tasks, especially in the healthcare industry. In this regard, it has become clear that healthcare professionals and doctors need to be informed and improve themselves on this subject (1). Therefore, it is important to investigate the level of artificial intelligence readiness among medical students (2).

The concept of artificial intelligence was first used in 1965. By modeling human learning, inference, and development, it makes it easier to automatically solve problems that are difficult to solve with simple calculations. It is thought to have its roots in the short story "Runaround", about a robot developed by engineers, published by Isaac Asimov in the 1940s. In the 1950s, Alan Turing developed a code-breaking machine called The Bombe, which is considered the first working electro-mechanical computer, and published an article explaining how to make smart machines and test their intelligence. The Turing Test described in this article is still used to determine the intelligence of an artificial system. Robotics, one of the places where artificial intelligence is used, is a type of artificial intelligence and is the combination of industrialized robots and computers. The robot is taught how the job should be done using artificial intelligence technology (3). Another type used is the simulation of human perception systems and skills such as vision, hearing and touch. These artificial intelligence skills can be achieved to a certain extent in today's technology. One of the artificial intelligence applications used in education is expert systems. Expert systems by definition; They are computer programs that perform the tasks of people who specialize in a certain field using many artificial intelligence algorithms. They work based on inference and knowledge. Expert systems are a branch of artificial intelligence. However, there are also features that distinguish it from artificial intelligence. Artificial intelligence mimics human intelligence when solving a problem; Expert systems, on the other hand, deal with problems that can be solved by experts on certain subjects. Expert systems are also used in distance education and provide individual answers and feedback to students (4).

The first interactions between medicine and artificial intelligence occurred in the 1960s with the creation of the Medical Literature Analysis and Retrieval System (MEDLINE) created by the National Library of Medicine and the web-based search engine PubMed (5). During this process, clinical informatics databases and medical record systems also began to be created for the first time. It was observed that the first studies of artificial intelligence in the field of medicine, which was built based on the "if, then" sequence after Alan Turing's idea of using the computer to simulate intelligent behavior and critical thinking, were on the manual diagnosis of diseases (6). CASNET (Causal Associational Networks), one of the first applications in which artificial intelligence was associated with medicine, is a consultation system created for glaucoma in the 1960s. This model can apply information about specific diseases to individual patients and guide doctors regarding treatment. MYCIN was developed in the early 1970s with the aim of diagnosing certain antimicrobial infections and recommending drug therapy. PIP (Present Illness Program) was developed to simulate the behavior of a nephrologist in taking the current disease history of a patient with underlying kidney disease. In the early 1982s, INTERNIST-1 was developed using a larger database than its predecessors to assist the primary care physician in diagnosis (7). Although all these developments are exciting, these systems have not reached widespread use. The focus has been on machine learning, also known as statistical learning, which is a completely data-driven learning procedure that avoids the hassle of manually coding rules. Machine learning represents a versatile learning framework roughly similar to artificial neural networks (8).

Machine learning analyzing large and complex data sets offers a very promising path to better understanding pathophysiology and, as a result, improving medical search, diagnosis, and treatment for millions of people with chronic and acute diseases (9). The spectrum of AI developments has also been expanded to provide treatment services. The revolution created by the American company Intuitive in the field of surgery, especially urological and gynecological surgeries, with its Da Vinci robotic surgery system can be given as an example (10). With the studies carried out, the areas of use of artificial intelligence in medicine are also expanding considerably. For example, with the digitalization of deep learning and medical image formats, which are sub-branches of artificial intelligence in the field of image processing, artificial intelligence has become extremely important in the field of healthcare. The aim here is to turn a process that can cause great difficulties in terms of cost and time in favor of patients, people and institutions involved in the research task (11). In recent years, there have been many clinical and basic science advances in artificial intelligence in the cardiovascular field, which has significantly reduced the mortality and morbidity rate in hundreds of thousands of patients. Some of these advances; heart failure and transplantation, advanced cardiac imaging, structural and interventional cardiology, and congenital cardiology (12).

Although medicine has experienced major changes in recent years, medical education is still largely based on traditional curricula and there are no accreditation requirements regarding artificial intelligence in medical education. However, at the 2018 annual meeting of the American Medical Association, it was seen that artificial intelligence encouraged research on how it should be handled in medical education, and it was predicted that this was a harbinger of changes (13). This lack of artificial intelligence integration in medical education poses a challenge to students in the transition from the pre-clinical environment to the clinical environment and how artificial intelligence knowledge can be applied and used in the clinical environment. This brings with it the need to teach machine learning and its applications in medical school and to train the next generation of clinicians and biomedical scientists to face data-driven challenges that may directly affect patient care in the coming years (14).

It is a fact that current medical school students will work with various artificial intelligence technologies when they start their working lives (15). In this case, it is important to examine whether medical school students' opinions about artificial intelligence, their current knowledge about artificial intelligence, and whether they have prejudices about the use of artificial intelligence. In this context, in a study examining medical faculty students' approaches to artificial intelligence, when physician candidates were asked whether they had heard of the concept of artificial intelligence before, it was determined that 93.6% of the students had heard of the concept of artificial intelligence before, and 6.4% had never heard of this concept before. In the same study, when students were asked whether artificial intelligence applications were useful in their medical lives, it was observed that 87% found artificial intelligence applications in health useful (16). This situation shows that most students studying at medical school are aware of artificial intelligence and are positive about using artificial intelligence in their professional lives. However, although it is rare, there is also a group of students who think that with the development of artificial intelligence technology, the physician's margin of error should be small, otherwise they may face pressure (17).

## MATERIAL AND METHODS

**Ethic Approval:** Ethics committee approval for this study, which aims to examine the knowledge level and awareness of Faculty of Medicine students about medical artificial intelligence technologies, was received on 26.04.2022 in Izmir Katip Celebi University Social Research Ethics Committee (2022/08-03). The data collection tools were prepared on Google Forms and the data was obtained between May 2022-February 2023. Participation in the study was completely voluntary. A survey form consisting of socio-demographic questions and the Medical Artificial Intelligence Readiness Scale for Medical Students-MAIRS-MS were administered online to the volunteers participating in the study.

**Sample Size:** Priori power analysis before the study was performed using the G*Power 3.1.9.4 program. In the comparison of the means of the medical artificial intelligence readiness total score according to more than two group categories (ANOVA: Fixed effects, omnibus one-way), considering the Type I error as 0.05, the minimum effect size as 0.10 and the power of the study as 0.80, 172 participants were included in this study.

**Data Collection:** The data was gathered using the "descriptive questionnaire" and " Medical Artificial Intelligence Readiness Scale (MAIRS-MS)". Medical Artificial Intelligence Readiness Scale was developed by Ozan Karaca, et al. in 2021. A four-factor structure emerged in the scale: Cognition (items 1-8), Ability (items 9-16), Vision (items 17-19) and Ethics (items 20-22). The validity and reliability of the scale was calculated by Ozan Karaca, et al. and the cronbach alpha reliability coefficient was calculated as 0.870, indicating high reliability (18).

The Medical Artificial Intelligence Readiness Scale for Medical Students (MAIRS-MS) scale reliability of this study was found to be 0.944. The Cronbach alpha value was calculated as 0.901 for cognition score items, 0.915 for ability score items, 0.816 for vision score items, and 0.837 for ethics score items. In our study, as a data collection method, an 18-item descriptive questionnaire, consisting of 3 demographic questions and 15 artificial intelligence questions was applied. It was aimed to determine the awareness of Faculty of Medicine students about the use of medical artificial intelligence with a survey consisting of closed-ended questions. Additionally, the Medical Artificial Intelligence Readiness Scale was administered to the participants. The scale consists of 4 factors (cognition, ability, vision, and ethics) and a total of 22 items, all of which are positive. The representation of the numbers to evaluate these items is determined as strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1) (19). In line with the participants' answers to the prepared questionnaire form and MAIRS-MS scores, the MAIRS-MS cognition, ability, vision, and ethics sub-dimensions scores were calculated, and the overall total score was obtained. Cognition, ability, vision and ethics subscale scores and MAIRS-MS score were considered as dependent variables. The descriptive questionnaire questions, prepared with closed-ended questions consisting of a total of 18 items, were considered as independent factors. MAIRS-MS score and sub-dimension score distributions were compared according to each category.

**Statistical Analysis:** The Shapiro-Wilk test was used for normality testing. Descriptive statistics are given as mean and standard deviation

(*Mean*±*SD*) or median ($Q_1$-$Q_3$) for continuous variables. Descriptive statistics for categorical variables are reported as frequencies and percentages. Homogeneity of variances was evaluated with the Levene test. In comparing the data of the descriptive questionnaire with the scale sub-dimensions and MAIRS-MS, it was evaluated with the Mann Whitney *U* test, considering the assumptions of normal distribution in case of two independent categories, and the One-way Analysis of Variance (ANOVA) or Kruskal Wallis test more than two independent categories. If there was a statistical difference between groups, Dunn's Bonferroni adjustment results were reported for pairwise comparisons. The relationship between the scale sub-dimensions and the MAIRS-MS scores was evaluated with the Spearman correlation coefficient. The reliability of the scale was determined by the Cronbach alpha value. The value of $p<0.05$ was determined as the level of statistical significance. The data were analyzed using the Statistical Package for Social Sciences (SPSS for Windows, 26.0, IBM corp., Armonk, NY, USA).

## RESULTS

A total of 172 students, 83 (48.3%) males and 89 (51.7%) females, took part in this study. The ages of the students range from 18-26, mean and standard deviation 20,86±1,464, median age is 21. Participation was provided from 12 different universities in Turkey, the majority of which were Izmir Katip Çelebi University (58.7%). Participation was provided from every year of the Faculty of Medicine, but it was observed that the participants were mostly students in years 3 (52.9%).

Table-1 shows the rates of response given to the descriptive questionnaire asked to the participants about artificial intelligence in medicine.

**Table 1.** Descriptive questionnaire regarding artificial intelligence readiness (*n*=172)

| **Questions** | No *n (%)* | Undecided *n (%)* | Yes *n (%)* |
|---|---|---|---|
| ***Q*1.** Do you think that artificial intelligence technology will contribute to the development of your profession? | 1 (0.6) | 38 (22.1) | 133 (77.3) |
| ***Q*2.** Do you think artificial intelligence technology will reduce your workload? | 7 (4.1) | 38 (22.1) | 127 (73.8) |
| ***Q*3.** Can you distinguish under what conditions you will or will not use artificial intelligence? | 13 (7.6) | 81 (47.1) | 78 (45.3) |
| ***Q*4.** Do you have enough knowledge to make the necessary explanation to patients who have concerns about artificial intelligence? | 49 (28.5) | 82 (47.7) | 41 (23.8) |
| ***Q*5.** Do you think that training on artificial intelligence will contribute to your profession? | 5 (2.9) | 45 (26.2) | 122 (70.9) |
| ***Q*6.** Does the use of artificial intelligence in the field of health conflict with your professional knowledge? | 81 (47.1) | 76 (44.2) | 15 (8.7) |
| ***Q*7.** Do you think that the use of artificial intelligence in health will reveal new treatments? | 14 (8.1) | 51 (29.7) | 107 (62.2) |
| ***Q*8.** Do you follow current information about artificial intelligence technologies in health? | 68 (39.5) | 65 (37.8) | 39 (22.7) |
| ***Q*9.** Can you foresee and prevent the negative effects that artificial intelligence technologies may cause you? | 31 (18.0) | 96 (55.8) | 45 (26.2) |
| ***Q*10.** Can you use artificial intelligence technologies in front of the patient in a way and method appropriate to the problem? | 21 (12.2) | 72 (41.9) | 79 (45.9) |
| ***Q*11.** Can you use artificial intelligence technologies within ethical principles while doing your job? | 10 (5.8) | 66 (38.4) | 96 (55.8) |
| ***Q*12.** Can you explain how artificial intelligence works and the benefits it brings to you? | 25 (14.5) | 81 (47.1) | 66 (38.4) |
| ***Q*13.** Does the use of artificial intelligence in healthcare conflict with your future goals? | 91 (52.9) | 66 (38.4) | 15 (8.7) |
| ***Q*14.** Do you think that artificial intelligence will create negativities if it is not used appropriately in healthcare? | 35 (20.3) | 45 (26.2) | 92 (53.5) |
| ***Q*15.** Do you think that using artificial intelligence technologies in healthcare will enable us to approach the patient more competently and, when necessary, more knowledgeably, and will help in the continuity of the patient's treatment? | 4 (2.3) | 51 (29.7) | 117 (68.0) |

MAIRS-MS score and subdimension mean and standard deviation (min-max) scores found to be that 70,37±16,01 (22-110) for MAIRS-MS; 23,00±6,70 (8-40) for cognition; 27,30±6,85 (8-40) for ability; 9,75±2,59 (3-15) for vision and 10,31±2,8 (3-15) for ethics, respectively. MAIRS-

MS reliability Cronbach alpha value was found to be 0.944, and 0.901, 0.915, 0.816 and 0.837 for the cognition, ability, vision, and ethics sub-dimensions.

The distribution of MAIRS-MS and sub-dimension scores according to response categories for the questions 1-8 is shown in Table 2. Artificial intelligence technology will contribute to the development of profession ($p$=0.003), reduce the workload ($p$<0.001), the ability to distinguish under what conditions will use it or not ($p$<0.001), they have enough knowledge to make the necessary explanation to patients who are concerned about artificial intelligence ($p$=0.003), the use of artificial intelligence in medicine does not conflict with your professional knowledge ($p$=0.011), MAIRS-MS scores were found to be higher in students who think that the use of artificial intelligence in health will reveal new treatments ($p$=0.001) and who follow current information about artificial intelligence technologies in medicine ($p$=0.006).

**Table 2.** The distribution of MAIRS-MS and sub-dimension scores according to response categories for question 1-8

| | | No *Mean±SD* or *Median* ($Q_1$-$Q_3$) | Undecided *Mean±SD* or *Median* ($Q_1$-$Q_3$) | Yes *Mean±SD* or *Median* ($Q_1$-$Q_3$) | *p* value |
|---|---|---|---|---|---|
| ***Q1*** | Cognition | - | 20 (17-24) | 24 (19.5-28) | **0.004**$^{+}$ |
| | Ability | - | 24 (17-30) | 29 (24-33) | **0.002**$^{+}$ |
| | Vision | - | 9 (6-11) | 10 (9-12) | **0.023**$^{+}$ |
| | Ethics | - | 9 (7-12) | 11 (9-12) | **0.029**$^{+}$ |
| | MAIRS-MS | - | 64.50 (45.75-74.25) | 73 (64-81) | **0.003**$^{+}$ |
| ***Q2*** | Cognition | 18 (13-24) $^{a}$ | 19.5 (17-25) $^{a}$ | 24 (20-28) $^{b}$ | **0.001**$^{+++}$ |
| | Ability | 24 (19-28) $^{a, b}$ | 23.50 (17.75-27.50) $^{a}$ | 30 (24-33) $^{b}$ | **<0.001**$^{+++}$ |
| | Vision | 9 (8-15) $^{a, b}$ | 8.5 (6-10.25) $^{a}$ | 10 (9-12) $^{b}$ | **0.002**$^{+++}$ |
| | Ethics | 9 (8-14) $^{a, b}$ | 9 (7-10.25) $^{a}$ | 11 (9-12) $^{b}$ | **0.002**$^{+++}$ |
| | MAIRS-MS | 66 (50-74) $^{a, b}$ | 63.5 (47-72) $^{a}$ | 74 (64-83) $^{b}$ | **<0.001**$^{+++}$ |
| ***Q3*** | Cognition | 20.16 ± 6.27 $^{a}$ | 22.30± 5.64 $^{a}$ | *27.78* ± 6.78 $^{b}$ | **<0.001**$^{++}$ |
| | Ability | 26 (21-30.50) $^{a}$ | 27 (23-32) $^{a}$ | 32 (24.5-36) $^{b}$ | **0.001**$^{+++}$ |
| | Vision | 9 (7-11) $^{a}$ | 10 (8-11) $^{a}$ | 11 (9-12.5) $^{b}$ | **0.003**$^{+++}$ |
| | Ethics | 10 (8-12) | 10 (9-12) | 12 (9-13.5) | 0.088$^{+++}$ |
| | MAIRS-MS | 66 (56-77) $^{a}$ | 71 (61-79) $^{a}$ | 81 (68.5-90) $^{b}$ | **<0.001**$^{+++}$ |
| ***Q4*** | Cognition | 20.08± 7.89 $^{a}$ | 21.77±5.63 $^{a}$ | 24.77± 7.12$^{b}$ | **0.004**$^{++}$ |
| | Ability | 23 (17.5-32) $^{a}$ | 25 (21-30) $^{a}$ | 32 (25.75-34) $^{b}$ | **<0.001**$^{+++}$ |
| | Vision | 9 (6.5-12.5) $^{a, b}$ | 9 (7-11) $^{a}$ | 11 (9-12) $^{b}$ | **0.003**$^{+++}$ |
| | Ethics | 9 (5.5-12) | 10 (8.5-12) | 12 (9-13) | **0.032**$^{+++}$ |
| | MAIRS-MS | 63.08± 21.27 $^{a}$ | 66.07 ± 13.53 $^{a}$ | 76.04 ± 15.74$^{b}$ | **<0.001**$^{++}$ |
| ***Q5*** | Cognition | 21.20±11.520 | 21.91±5.067 | 23.48±6.99 | 0.340$^{++}$ |
| | Ability | 23 (14-23) $^{a}$ | 25 (19-29.5) $^{a}$ | 30 (24-33) $^{b}$ | **<0.001**$^{+++}$ |
| | Vision | 7 (5-10) $^{a}$ | 9 (6-11) $^{a}$ | 10 (9-12) $^{b}$ | **0.026**$^{+++}$ |
| | Ethics | 9 (6-13) $^{a, b}$ | 9 (7-11) $^{a}$ | 11 (9-13) $^{b}$ | **0.002**$^{+++}$ |
| | MAIRS-MS | 65 (36.5-74.5) $^{a, b}$ | 66 (54.5-73) $^{a}$ | 74 (63-83) $^{b}$ | **0.003**$^{+++}$ |
| ***Q6*** | Cognition | 24.43±7.10 $^{a}$ | 21.25±6.30 $^{b}$ | 24.13±4.14 $^{a, b}$ | **0.009**$^{++}$ |
| | Ability | 30 (24-33.5) $^{a}$ | 25.5 (20.25-31) $^{b}$ | 26 (24-33) $^{a, b}$ | **0.015**$^{+++}$ |
| | Vision | 10 (9-12) | 9 (7-11) | 10 (7-12) | 0.112$^{+++}$ |
| | Ethics | 11 (9-13) $^{a}$ | 10 (8-12) $^{a, b}$ | 9 (8-10) $^{b}$ | **0.013**$^{+++}$ |
| | MAIRS-MS | 76 (65-85) $^{a}$ | 67 (57.25-78) $^{b}$ | 66 (63-80) $^{a, b}$ | **0.011**$^{+++}$ |
| ***Q7*** | Cognition | 20.50 (15-24) $^{a}$ | 22 (18-25) $^{a}$ | 24 (19-29) $^{b}$ | **<0.001** |
| | Ability | 28.5 (21-33.25) $^{a, b}$ | 24 (18-28) $^{a}$ | 30 (24-33) $^{b}$ | **<0.001**$^{+++}$ |
| | Vision | 10 (6.75-12) $^{a, b}$ | 9 (6-10) $^{a}$ | 10 (9-12) $^{b}$ | **0.008**$^{+++}$ |
| | Ethics | 9.5 (7.75-13.25) $^{a, b}$ | 9 (8-11) $^{a}$ | 11 (9-13) $^{b}$ | **0.035**$^{+++}$ |
| | MAIRS-MS | 65.36±19.54 $^{a, b}$ | 64.45± 14.10 $^{a}$ | 73.84± 15.52$^{b}$ | **0.001**$^{++}$ |
| ***Q8*** | Cognition | 20.97± 7.46 $^{a}$ | 22.38± 4.32 $^{a}$ | 27.56± 6.54 $^{b}$ | **<0.001**$^{++}$ |
| | Ability | 28 (23-32.75) | 26 (23-31) | 32 (24-35) | 0.069$^{+++}$ |
| | Vision | 10 (7-11) $^{a}$ | 10 (7-11) $^{a}$ | 10 (9-12) $^{b}$ | **0.014**$^{+++}$ |
| | Ethics | 11 (8-12) | 11 (9-12) | 10 (9-13) | 0.771$^{+++}$ |
| | MAIRS-MS | 70 (59.25-79.75) $^{a}$ | 71 (61.5-78) $^{a}$ | 76 (66-88) $^{b}$ | **0.006**$^{+++}$ |

$^{+}$Mann Whitney *U* test; $^{++}$ One way Analysis of Variance (ANOVA); $^{+++}$ Kruskal Wallis test

Superscripts *a* and *b* indicate the difference between groups mean or median. Any measurements with shared superscript letters are not significantly different from each other at *p*<0.05 with Dunn-Bonferroni adjustment.

The distribution of MAIRS-MS and sub-dimension scores according to response categories for the questions 9-15 is shown in Table 3. The students' MAIRS-MS scores were found to be higher who can foresee and prevent the negative effects that artificial intelligence technologies may create ($p<0.001$), can use artificial intelligence technologies in a way and method appropriate to the problem in front of the patient ($p<0.001$). Also, it has been observed that students who can use artificial intelligence technologies within the framework of ethical principles ($p<0.001$), explain how artificial intelligence works and the benefits it provides ($p<0.001$), use artificial intelligence in health services and do not conflict with their future goals have higher MAIRS-MS scores ($p<0.001$). MAIRS-MS scores were also high for the students who thought that using artificial intelligence technologies in medicine, which could lead to negativities if not used correctly in medicine ($p=0.006$), would enable them to approach the patient more competently and, when necessary, more knowledgeably, and would help the continuity of the patient's treatment ($p<0.001$).

**Table 3.** The distribution of MAIRS-MS and sub-dimension scores according to response categories for question 9-15

| | | No<br>*Mean±SD* or<br>*Median* ($Q_1$-$Q_3$) | Undecided<br>*Mean±SD* or<br>*Median* ($Q_1$-$Q_3$) | Yes<br>*Mean±SD* or<br>*Median* ($Q_1$-$Q_3$) | *p* value |
|---|---|---|---|---|---|
| ***Q9*** | Cognition | 19.26±6.55 $^{a}$ | 22.85±5.81 $^{b}$ | 25.89±7.32 $^{c}$ | **<0.001** $^{++}$ |
| | Ability | 24.68± 8.62 $^{a}$ | 27.15±5.88 $^{a, b}$ | 29.44±6.90 $^{b}$ | **0.010**$^{++}$ |
| | Vision | 9 (6-12) $^{a}$ | 10 (8-11) $^{a}$ | 11 (9-12) $^{b}$ | **0.002**$^{+++}$ |
| | Ethics | 9 (6-12) $^{a}$ | 11 (9-12) $^{b}$ | 11 (9-13) $^{b}$ | **0.021**$^{+++}$ |
| | MAIRS-MS | 61.58± 18.57 $^{a}$ | 70.09±13.33 $^{b}$ | 77.00±16.68 $^{c}$ | **<0.001**$^{++}$ |
| ***Q10*** | Cognition | 19.43±7.51 $^{a}$ | 21.60±5.76 $^{a}$ | 25.23±6.58 $^{b}$ | **<0.001** $^{++}$ |
| | Ability | 21 (17-24.5) $^{a}$ | 26 (23-30) $^{b}$ | 32 (26-34) $^{c}$ | **<0.001**$^{+++}$ |
| | Vision | 7 (6-10) $^{a}$ | 9.5 (7-11) $^{a}$ | 11 (9-12) $^{b}$ | **<0.001**$^{+++}$ |
| | Ethics | 8 (5.5-9.5) $^{a}$ | 10 (9-12) $^{b}$ | 12 (9-13) $^{b}$ | **<0.001**$^{+++}$ |
| | MAIRS-MS | 55.62± 18.14 $^{a}$ | 66.96± 12.18$^{b}$ | 77.39±14.95 $^{c}$ | **<0.001**$^{++}$ |
| ***Q11*** | Cognition | 20.50±4.33 $^{a, b}$ | 20.36± 6.09 $^{a}$ | 25.07±6.61 $^{b}$ | **<0.001** $^{++}$ |
| | Ability | 19 (17.75-27.75) $^{a}$ | 24 (19-28) $^{a}$ | 31 (26-34) $^{b}$ | **<0.001**$^{+++}$ |
| | Vision | 8 (6-12) $^{a. b}$ | 9 (6-10) $^{a}$ | 11 (9-12) $^{b}$ | **<0.001**$^{+++}$ |
| | Ethics | 7.5 (6-12.25) $^{a}$ | 9 (8-11) $^{a}$ | 12 (9-13) $^{b}$ | **<0.001**$^{+++}$ |
| | MAIRS-MS | 59.5 (47-75) $^{a}$ | 64 (53.75-70.25) $^{a}$ | 77 (69.6-85) $^{b}$ | **<0.001**$^{+++}$ |
| ***Q12*** | Cognition | 19.20±7.32 $^{a}$ | 21.94±5.37 $^{a}$ | 25.74±6.93 $^{b}$ | **<0.001** $^{++}$ |
| | Ability | 23.04± 7.34 $^{a}$ | 25.30± 6.21 $^{a}$ | 31.38±5.22$^{b}$ | **<0.001** $^{++}$ |
| | Vision | 8 (6-9.5) $^{a}$ | 9 (7-11) $^{a}$ | 11 (10-12) $^{b}$ | **<0.001**$^{+++}$ |
| | Ethics | 8 (5.5-9) $^{a}$ | 10 (8.5-12) $^{b}$ | 12 (9.75-13) $^{c}$ | **<0.001**$^{+++}$ |
| | MAIRS-MS | 58.20± 17.12 $^{a}$ | 66.48± 13.04 $^{b}$ | 79.74±13.86 $^{c}$ | **<0.001** $^{++}$ |
| ***Q13*** | Cognition | 23.99±7.16 $^{a}$ | 21.03±5.65$^{b}$ | 25.67± 0.14 $^{b}$ | **0.006** $^{++}$ |
| | Ability | 31 (26-33) $^{a}$ | 24 (18.75-29) $^{b}$ | 25 (23-29) $^{a. b}$ | **<0.001**$^{+++}$ |
| | Vision | 10 (9-12) $^{a}$ | 9 (6-11) $^{b}$ | 12 (10-12) $^{a}$ | **<0.001**$^{+++}$ |
| | Ethics | 11 (9-13) $^{a}$ | 9 (7.75-12) $^{b}$ | 9 (8-12) $^{a. b}$ | **0.007**$^{+++}$ |
| | MAIRS-MS | 77 (67-84) $^{a}$ | 64 (55-73) $^{b}$ | 71 (65-74) $^{a. b}$ | **<0.001**$^{+++}$ |
| ***Q14*** | Cognition | 26.20±7.49 $^{a}$ | 21.84±5.235 $^{b}$ | 22.35±6.71 $^{b}$ | **0.006** $^{++}$ |
| | Ability | 27 (23-32) $^{a, b}$ | 24 (18-29) $^{a}$ | 30 (24-33) $^{b}$ | **0.001**$^{+++}$ |
| | Vision | 10 (9-12) $^{a, b}$ | 9 (7-10.5) $^{a}$ | 10.5 (9-12) $^{b}$ | **0.024**$^{+++}$ |
| | Ethics | 10 (9-13) $^{a, b}$ | 9 (8-11) $^{a}$ | 11 (9-12) $^{b}$ | **0.025**$^{+++}$ |
| | MAIRS-MS | 76 (61-85) $^{a}$ | 66 (55-73) $^{b}$ | 73.5 (64.25-81.75) $^{a}$ | **0.006**$^{+++}$ |
| ***Q15*** | Cognition | 21.50 (14.25-25) $^{a, b}$ | 21 (17-24) $^{a}$ | 24 (19.50-29) $^{b}$ | **0.010**$^{++}$ |
| | Ability | 24.50 (20.25-34.75) $^{a, b}$ | 24 (18-27) $^{a}$ | 31 (25-34) $^{b}$ | **<0.001**$^{+++}$ |
| | Vision | 7.5 (6-12.75) $^{a, b}$ | 9 (6-10) $^{a}$ | 10 (9-12) $^{b}$ | **<0.001**$^{+++}$ |
| | Ethics | 9.5 (6.75-13.75) $^{a, b}$ | 9 (7-10) $^{a}$ | 12 (9-13) $^{b}$ | **<0.001**$^{+++}$ |
| | MAIRS-MS | 63.5 (52.75-80.25) $^{a, b}$ | 64 (50-70) $^{a}$ | 76 (65.5-84.5) $^{b}$ | **<0.001**$^{+++}$ |

$^{++}$ One way Analysis of Variance (ANOVA); $^{+++}$ Kruskal Wallis test
Superscripts *a, b* and *c* indicate the difference between groups mean or median. Any measurements with shared superscript letters are not significantly different from each other at $p<0.05$ with Dunn-Bonferroni adjustment

The relationship between the sub-dimension of the scale and the MAIRS-MS score was examined with Spearman correlation analysis. There was statistically significant moderately positive relationship between cognition and ability (*rho*=0.535; $p<0.001$); cognition and vision (*rho*=0.402; $p<0.001$); cognition and ethics (*rho*=0.402; $p<0.001$); ability and vision (*rho*=0.668; *p*<0.001); ability and ethics (*rho*=0.686; *p*<0.001); vision and ethics (*rho*=0.587; *p*<0.001). It was observed that there was a strong positive relationship between ability and MAIRS-MS (*rho*=0.895; *p*<0.001); cognition and MAIRS-MS (*rho*=0.788; *p*<0.001); vision and MAIRS-MS (*rho*=0.720; *p*<0.001); ethics and MAIRS-MS (*rho*=0.730; *p*<0.001).

## DISCUSSION

This study aims to evaluate the medical artificial intelligence (AI) readiness levels of students at Medical Faculties in Turkey. Their readiness was measured through the total marks that the students scored on the medical AI readiness scale, which included four factors: cognition, ability, vision, and ethics. A higher score indicated a higher agreement with the questionnaire statements, and a higher level of readiness towards AI among medical students in Turkey.

Most students in this study had a mean score on the MAIRS-MS. This result is supported by a previous a cross-sectional study in Malaysia and cohort study in the United Kingdom. Results of the study conducted with 105 participants in Malaysia showed that the mean score of readiness for artificial intelligence was 75.04. The mean scores of cognition, ability, vision, and ethics factors were found as respectively 27.61; 27.17; 10.19 and 10.07. From these mean scores, the total score of the majority of medical school students (67.62%) is 53-83 points, followed by 24.76% of the students with a total score of 84-114 points and 7.62% of the students with a total score of 84-114 points. It was determined that students who score a total of 22-52 on MAIRS-MS. This showed that most of the students had average scores on MAIRS-MS (20). Almost half of a total of 484 medical students at UK medical schools stated that they had a clear understanding of the basic computational principles that underpin artificial intelligence (21).

According to our findings, participants think that medical artificial intelligence has positive results in the field of medicine, but they do not feel fully ready for it. Most of our participants studying at Medical Faculties in Turkey think that artificial intelligence will contribute to their profession and education and reduce their workload. Most people have concluded that the use of artificial intelligence technologies in healthcare will enable us to approach the patient more competently and, when necessary, more knowledgeably, and will also help in the continuity of the patient's treatment (22).

Due to the impact of artificial intelligence on medicine and medical education, many studies have evaluated medical students’ views on artificial intelligence, aiming to bring further improvements to this method (23). Abid et al. investigated Pakistani medical students’ attitudes and readiness towards AI (24). On the other hand, there are significant issues regarding knowledge, attitude, and preparedness regarding artificial intelligence in some developing countries. Hamd et al. the study results showed a lack of education and training programs for the implementation of AI, and from their perspective, organizations were not well prepared and had to ensure their AI readiness (25). In the United Arab Emirates, Boillat et al. They reported unfamiliarity with AI and called for specific training in medical schools and hospitals to enable them to use this new paradigm to improve healthcare delivery and clinical outcomes (26). The differences between developed and developing countries appear to be largely driven by curriculum designs, particularly the role or lack thereof of artificial intelligence. For this reason, it is recommended that medical faculties consider information sharing mechanisms about artificial intelligence and develop curricula that will teach the use of artificial intelligence tools as a competence (27).

It is of great importance to use artificial intelligence in harmony with the values of society and to protect human rights. Privacy and security of personal data is a fundamental ethical issue that must be considered in the use of artificial intelligence systems. In the questions asked under the ethics sub-dimension, the majority said that they could act in accordance with ethical principles when using artificial intelligence in medicine.

This original research has some minor limitations. We collected data from 6 different public medical schools, mostly from the Aegean and Mediterranean geographical regions, and therefore the findings may not be generalizable to most public and private medical schools. Additionally, the study was conducted only in Turkey. Therefore, although the probability of this difference is very small, the results may not be generalizable to other countries. The findings presented in this study need to be examined carefully considering differences between countries and cultures.

## CONCLUSION

Artificial intelligence refers to systems or machines that mimic human intelligence to perform tasks and gradually improve themselves with the information they collect. With this technology, which we use everywhere in our lives and almost all day, especially in medical education and the health sector, information and complex processes and repetitive important tasks can be facilitated. Therefore, it is important to investigate the level of artificial intelligence readiness among medical students. When the findings are evaluated, it is seen that the students' awareness level about medical artificial intelligence is high, and they have the skills to use artificial intelligence technologies. However, it was observed that their self-confidence in technical matters was not very high. The idea has arisen that education on these issues should be emphasized and the self-confidence of medical students should be increased in artificial intelligence skills.

**REFERENCES**


1. Isler B, Kılıç M. Eğitimde yapay zekâ kullanımı ve gelişimi. Yeni Medya Elektronik Dergisi. 2021;5(1):1-11.
2. Hinton G. Deep learning a technology with the potential to transform health care. Jama. 2018;320(11):1101-2.
3. Haenlein M, Kaplan A. A brief history of artificial intelligence: On the past, present, and future of artificial intelligence. California management review. 2019;61(4):5-14.
4. Onder HH. Uzaktan Egitimde Bilgisayar Kullanimi ve Uzman Sistemler. TOJET: The Turkish Online Journal of Educational Technology. 2003;2(3).
5. Doğaç A. MYCIN I- Uzman Sistemler. Elektrik Mühendisliği. 2015;7(7):87-91.
6. Kaul V, Enslin S, Gross SA. History of artificial intelligence in medicine. Gastrointestinal endoscopy. 2020;92(4):807-12.
7. Ishak WHW, Siraj F. Artificial intelligence in medical application: An exploration. Health Informatics Europe Journal. 2002;16.
8. Kulikowski CA. Beginnings of artificial intelligence in medicine (AIM): computational artifice assisting scientific inquiry and clinical art–with reflections on present aim challenges. Yearbook of medical informatics. 2019;28(01):249-56.
9. Atlan F, Pence I. Yapay Zekâ ve Tıbbi Görüntüleme Teknolojilerine Genel Bakış. Acta Infologica, 2021;5(1):207-30.
10. Malik P, Pathania M, Rathaur VK. Overview of artificial intelligence in medicine. Journal of family medicine and primary care. 2019;8(7):2328.
11. Xing L, Giger ML, Min JK (Eds.). Artificial intelligence in medicine: technical basis and clinical applications. Academic Press; 2020.
12. Russak AJ, Chaudhry F, De Freitas JK, Baron G, Chaudhry FF, Bienstock S, et al. Machine learning in cardiology ensuring clinical impact lives up to the hype. Journal of Cardiovascular Pharmacology and Therapeutics. 2020;25(5):379-90.
13. Paranjape K, Schinkel M, Panday RN, Car J, Nanayakkara P. Introducing artificial intelligence training in medical education. JMIR medical education. 2019;5(2):e16048.
14. Kolachalama VB, Garg PS. Machine learning and medical education. NPJ digital medicine. 2018;1(1):54.
15. Park SH, Do KH, Kim S, Park JH, Lim YS. What should medical students know about artificial intelligence in medicine? Journal of educational evaluation for health professions, 2019;16.
16. Ocal EE, Emrah AT, Onsuz MF, Algın F, Cokyigit FK, Kılınc S, Kose OS, Yigit FN. Tıp fakültesi öğrencilerinin tıpta yapay zekâ ile ilgili düşünceleri. Türk Tıp Öğrencileri Araştırma Dergisi. 2020;2(1):9-16.
17. Guo J, Li B. The application of medical artificial intelligence technology in rural areas of developing countries. Health equity. 2018;2(1):174-81.
18. Caliskan SA, Demir K, Karaca O. Sağlık Çalışanları Yapay Zekaya Hazır Mı? Are Healthcare Workers Ready for Artificial Intelligence? Journal of Artificial Intelligence in Health Sciences. 2021;1(1):35-5.
19. Karaca O, Caliskan SA, Demir K. Medical artificial intelligence readiness scale for medical students (MAIRS-MS)-development, validity and reliability study. BMC medical education. 2021; 21:1-9.
20. Xuan PY, Fahumida MIF, Al Nazir Hussain MI, Jayathilake NT, Khobragade S, Soe HHK, Moe S, Htay MNN. Readiness towards artificial intelligence among undergraduate medical students in Malaysia. Education in Medicine Journal. 2023;15(2):49–60.
21. Sit C, Srinivasan R, Amlani A, Muthuswamy K, Azam A, Monzon L, et al. Attitudes and perceptions of UK medical students towards artificial intelligence and radiology: a multicentre survey. Insights into Imaging. 2020;11(1):14.
22. Gherheș V, Obrad C. Technical and humanities students' perspectives on the development and sustainability of artificial intelligence (AI). Sustainability. 2018;10(9):3066.
23. Moodi GA, Moghadasin M, Emadzadeh A, Mastour H. Psychometric properties of the persian version of the Medical Artificial Intelligence Readiness Scale for Medical Students (MAIRS-MS). BMC Medical Education, 2023; 23(1):577.
24. Abid S, Awan B, Ismail T, Sarwar N, Sarwar G, Tariq M, et al. Artificial intelligence: medical student s attitude in district Peshawar Pakistan. Pakistan J Public Health. 2019;9(1):19–21.
25. Hamd Z, Elshami W, Al Kawas S, Aljuaid H, Abuzaid MM. A closer look at the current knowledge and prospects of artificial intelligence integration in dentistry practice: a cross-sectional study. Heliyon. 2023;9(6):e17089.
26. Boillat T, Nawaz FA, Rivas H. Readiness to Embrace Artificial intelligence among medical doctors and students: questionnaire-based study. JMIR Med Educ. 2022;8(2):e34973.
27. Hashimoto DA, Johnson KB. The Use of Artificial Intelligence Tools to prepare Medical School Applications. Acad Med. 2023.