Investigation of Physicians' Attitudes Towards Artificial Intelligence: A Qualitative Study

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Abstract

Background: The rapid adoption of artificial intelligence (AI) in healthcare emphasizes the importance of assessing healthcare professionals' attitudes towards this technology.

Objective: The aim of this study was to develop and validate a reliable and comprehensive Artificial Intelligence Attitude Scale (AIAS) with a number of subscales for physicians.

Methods: This qualitative study was conducted cross-sectionally between January and March 2024. For this investigation, three stages were identified. The first stage involves the development of an item pool pertaining to artificial intelligence and informatics. The next stage entails administering the generated items to a primary sample of physicians using a 5-point Likert questionnaire, followed by conducting explanatory and confirmatory factor analyses on the acquired data. The last stage consists of distributing the newly established scale to a secondary sample of physicians, assessing the scores across the scale's subcategories, and investigating their variations concerning certain independent variables.

Results: A questionnaire comprising 47 items was distributed to clinicians following an expert evaluation. The initial sample consisted of 239 participants who completed the questionnaire. After the outliers were eliminated, the results of 198 participants were analyzed. Exploratory factor analysis (EFA) identified a three-factor structure (Belief, Knowledge, Practice) with robust factor loadings (0.64 and above) and an overall explained variance of 62.64%. The data set was considered appropriate for EFA according to the Kaiser-Mayer-Olkin (KMO) (0.91) and Bartlett's test (?2=712.63, P<.001), and the principal axis factoring method with varimax rotation was utilized due to the lack of multivariate normality. After confirmatory factor analysis (CFA), the scale's (AIAS) final version comprised 26 items and three subscales emerged: belief (11 items), knowledge (7 items) and practice (8 items). All t values of the loadings of these subscales were significant (P<.001). The AIAS showed strong internal consistency (Cronbach's alpha >0.88 and composite reliability >0.70 for all subscales) and acceptable model fit indices in CFA. The AIAS was administered to a second new sample of 509 physicians in the concluding stage of the study, and 441 responses from this sample were considered to be valid. Findings revealed that physicians generally held positive beliefs about AI (mean belief score: 37.58 ± 9.22), but knowledge (18.71 ± 5.81) and practice (11.31 ± 3.7) scores remained lower. Male physicians (P<.001), those in academic roles (P<.001) and those working in private hospitals (P<.05) generally reported higher scores on some subscales, while higher workload was associated with lower practice scores (P<.05).

Conclusions: The AIAS provides a robust tool to assess attitudes towards AI in healthcare. While physicians recognize the potential benefits of AI, practical adoption requires targeted training, improved infrastructure and addressing ethical challenges.

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Keywords: Physician; artificial intelligence; attitude; scale; scale development **Introduction**

Entering our world in 1955, the concept of artificial intelligence (AI) [1], after spending "two great winters" [2], seems to have entered a spring that will last a very long time by catching a rapid and intense exit and dominating many scientific, industrial and professional fields.

The use of AI has also started to take an important place in health. When scientific research on health is examined, there are currently over 240,000 studies as a result of a search with the keyword "artificial intelligence" from the Pubmed database of the US National Center for Biotechnology. And more than 50% of these studies belong to 2020 and beyond, and especially China and the USA stand out in the bibliometric analysis of this field [3]. It is noteworthy that recent studies have shown that some diagnostic algorithms created with artificial intelligence show results so good that they rival or even surpass the performance of healthcare professionals [4].

There is a serious interest and demand for the managerial use of AI in health applications. For example, it is estimated that the use of AI in clinical decision support systems in China will create an economic value of 5 billion dollars [5]. On the other hand, an AI-based hospital command center was established in a health institution and it was stated that the transfer of patients, waiting times in the emergency department and bed management in the post-operative process were significantly facilitated and accelerated [6].

While AI-based research and applications in health are progressing in this way and keeping all AI enthusiasts so busy, it is seen that the awareness of AI among healthcare professionals or the feeling it arouses may not be in the same way and/or in the same direction. In a survey, a majority of physicians found AI useful for the field of medicine, while some even stated that AI could replace them in their workplaces [7]. Some healthcare professionals may also see AI as a threat to their future [8]. Details such as lack of trust in digital health technologies, fear of losing clinical skills and increased workload [9] may also affect their awareness of AI and create barriers against it due to its use in these fields.

It has become a scientific necessity to know and measure the inevitable and unavoidable positive and/or negative physician reaction to AI, which has rapidly entered into health practices. However, there is no scale evaluating physicians' AI attitude and/or awareness in literature. A scale with sufficient reliability to be developed on this occasion will contribute a useful tool to the scientific world.

Materials and Method Ethical

Approval

This study was approved by Ordu University Ethics Committee (Approval Date: 22.12.2023, No: 2023/336) and the research process was conducted in accordance with the Declaration of Helsinki. Participant confidentiality will be of utmost importance and therefore all personal data will be stored securely and accessed only by the researchers.

Study Design

This qualitative study was conducted cross-sectionally between January and March 2024. This research identified all physicians in Turkey as the target group. For this investigation, three stages were identified. The first stage involves the development of an item pool pertaining to artificial intelligence and informatics.

In the second stage, a collection of opinions and statements pertaining to artificial intelligence and informatics was established. These items were evaluated by professional and research experts. The item pool was delivered to physicians across the country to determine the factor structure. The relevant items were in the form of a questionnaire with five-point Likert responses. This questionnaire, which was created on a digital platform, was delivered to physicians via e-mail and social media. At this stage, factor analysis and reliability analysis of the responses obtained were performed and a new scale was created.

In the last stage, the acquired scale was administered to a new sample representative of the whole nation, and the individuals were analyzed based on subscale averages across several independent variable subgroups. This necessitated determining the minimal number of participants in the second sample. The Turkish Health Statistics Yearbook indicates that the total number of physicians in Turkey reached 194,688 in 2022 [10]. The sample size was determined using a 95% confidence level (⍰=1.96), a margin of error on a 5-point Likert scale (⍰=0.15), a standard deviation (⍰=1.25), and the specified population size (□=194,688). The calculations indicated that the minimum necessary sample size for the investigation is 266. Finally, at this stage, an analysis was performed on the distribution of the scores that were acquired from the scale in the sub-levels of the independent variables.

Data type and Data Analysis

The data type consisted of demographic information of the participants, responses to questions about their work experience and responses to the measurement questions/items.

The data received by filling out the digital forms were collected in an Excel file on the server infrastructure where the relevant digital form was located. The data sets formed here were analyzed with SPSS 24, LISREL and R programs.

We initially conducted exploratory factor analysis (EFA) to determine the factor structure. We then employed confirmatory factor analysis (CFA) to verify the factor structure that emerged from the EFA. Following the scale development process, descriptive statistics, including the minimum and maximum scores obtainable from the scales, were evaluated alongside the arithmetic mean and standard deviation values. Prior to comparing the means of the independent variables, the normality of score distributions was examined. This examination utilized various methods, including the Kolmogorov-Smirnov and Shapiro-Wilk tests, skewness and kurtosis coefficients, and skewness and kurtosis z-values. Distributions meeting these criteria were considered to follow a normal distribution. We applied an independent samples t-test to compare the means of the independent variables, and used a one-way analysis of variance for cases with more than two sublevels.

Results Developing the Questionnaire Items

The researchers proposed a questionnaire, which, after expert examination, was determined to comprise 47 elements. It was constructed using a 5-point Likert scale and distributed to the initial sample of physicians.

Analysis of Initial Sample Results

Exploratory Factor Analysis

In the first stage, the questionnaire consisting of 47 items was delivered to 239 physicians, and as a result of examining the univariate and multivariate outliers in this data set and excluding them from the study, the analyses were carried out with 198 people in the final stage. Exploratory factor analysis (EFA) was applied to reveal the factor structure of this first data set. This sample size is considered sufficient by various authors [11–13].

It was determined that the Kaiser-Mayer-Olkin test performed to test the suitability of the data set for exploratory factor analysis was .91 and the chi-square value of Barlett's test of sphericity was significant ($\chi 2$=712.63, *P*<.001). Accordingly, it can be said that the data set is appropriate in terms of sampling and that the variance covariance matrix is not equal due to the presence of relationships between the variables.

As a result of the analysis, it was determined that the multivariate kurtosis coefficient was 21.10 and the multivariate skewness coefficient was 5759.22; therefore, Mardia's kurtosis and skewness coefficients were not in the acceptable range and the data structure did not show multivariate normality (*P*<.001) [14]. It is recommended to use the Principal Axis Factoring method, one of the factor extraction methods, for a data structure that does not have multivariate normality [15]. At the same time, varimax orthogonal rotation method was used because the relationships between the factors were below the medium level [16].

Eigenvalues, parallel analysis and scree-slope-accumulation graphs were used to decide on the factor structure along with the theoretical framework. As a result of the analysis, real and simulated eigenvalues were compared and it was determined that a 3 (three) factor structure was formed. The graph of the eigenvalue of the parallel analysis and the graph of the slope-deposition are presented in Figure 1.

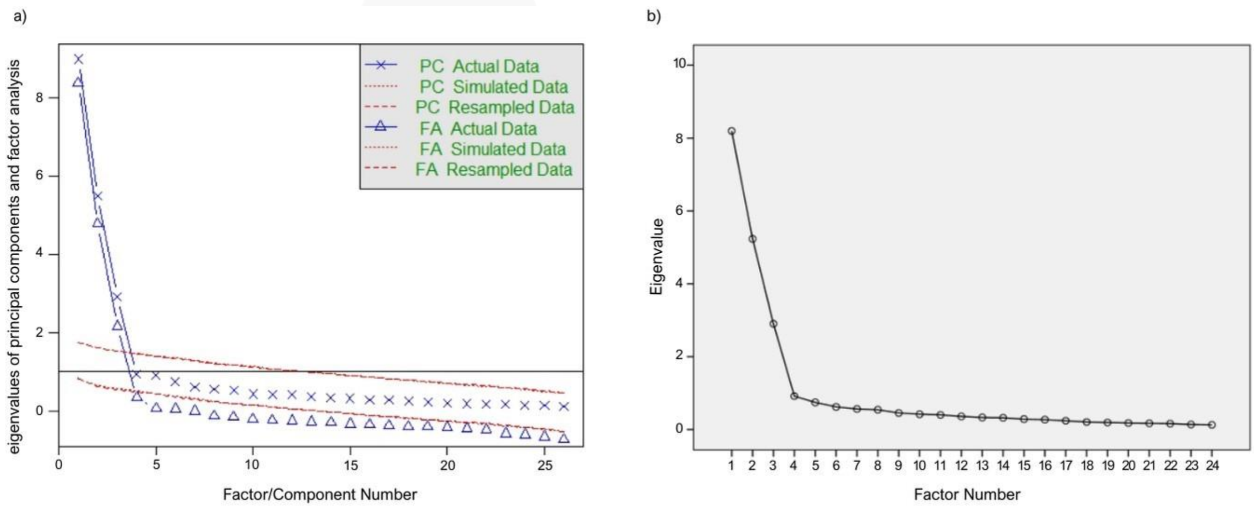

Figure-1. a) Parallel analysis eigenvalue graph, b) Slope-deposition graph

When the graphs are examined, it is seen that the slope decreases and linearizes after the 3rd factor. In addition, when the eigenvalues were examined, it was seen that the first three factors made a significant contribution to the structure and they were compatible with the theoretical framework. Therefore, it was decided that the scale structure should be three-factor. When the literature was examined, it was evaluated as very good because the factor loading value was .63 and explained 41% of the variance [12]. For the common variance coefficient, values close to or above .40 were reported to be items that made a significant contribution [17]. At the same time, it was stated that if an item showed high factor loadings in more than one factor, it was considered to be a cross-loaded item and these items disrupted the structure; therefore, there should be at least .10 difference between the loadings in more than one factor [18]. Analyses were conducted by taking all these criteria into consideration. The results of the exploratory factor analysis of the scale of attitudes towards artificial intelligence are given in Table 1.

Table-1. Explanatory factor analysis results of the scale of attitudes towards artificial intelligence.

Factor	Item No	Factor Loadings			Common Variance
		Factor 1	Factor 2	Factor-3	
		.87	.14	-.01	
	M34	**.86**	.15	-.04	.76
Factor-1 (Belief Dimension)	M39	**.85**	.17	.03	.74
	M37	**.84**	.10	.08	.71
	M38	**.83**	.10	.08	.71
	M33	**.82**	.11	.00	.68
	M40	**.76**	.06	.00	.57
	M36				.78
	M35	**.73**	.06	.09	.54
	M47	**.71**	.14	-.02	.52
	M29	**.69**	.24	.01	.53
	M28	**.68**	.27	-.01	.54
		Variance Explained %			**33.19**

Factor-2 (Knowledge Dimension)	M2	.15	**.88**	.11	.80
	M3	.12	**.88**	.15	.80
	M4	.16	**.79**	.31	.75
	M7	.12	**.79**	.22	.68
	M5	.19	**.76**	.20	.66
	M6	.15	**.72**	.20	.58
	M1	.07	**.71**	.07	.51
		Variance Explained %		**19.67**	
Factor-3 (Practice Dimension)	M25	.04	.13	**.80**	.65
	M22	-.01	.10	**.77**	.61
	M21	-.02	.04	**.75**	.56
	M16	.01	.19	**.72**	.56
	M26	.11	.27	**.72**	.60
	M14	-.06	.10	**.71**	.52
	M20	.05	.12	**.68**	.48
	M15	.06	.24	**.64**	.47
		Variance Explained %		**9.79**	
		Total Explained Variance		**62.64**	

When Table-1 is examined, it is seen that 17 items were excluded from the study due to low factor loadings and 6 items were excluded due to cross-loaded items. All of the remaining items had factor loadings of .64 and above and common variance coefficients of 0.47 and above. As a result of the analysis, Factor-1 (Belief Dimension), Factor-2 (Knowledge Dimension) and Factor-3 (Practice Dimension) were determined as the sub-factors of the scale of attitudes towards artificial intelligence. It is seen that the belief sub-factor consists of 11 (eleven) items, the factor loadings are between .71-.87 and the variance ratio it explains is 33.19. Another sub-factor, the knowledge factor, consisted of 7 items, with factor loadings between 0.71-0.88 and a variance ratio of 19.67. Finally, the practice sub-factor consisted of 8 items, the factor loadings ranged between .64-.80 and the variance explained by it was 9.79. It was seen that the total explained variance ratio of the attitude scale on artificial intelligence with three sub-factors was 62.64.

Confirmatory Factor Analysis Results

Confirmatory factor analysis was applied to determine the accuracy of the results of the exploratory factor analysis and to test the factor structure over a different sample. Within the scope of confirmatory factor analysis, since the relevant data structure did not show normal distribution characteristics, the analyses were performed on the asymptotic covariance matrix. The 26-item structure obtained within the scope of the exploratory factor analysis was associated with the 3 factors in question and the analyses were carried out. The standardized path coefficients and t values obtained as a result of the analysis are shown in Table 2.

Table-2. The final version of the 26-item artificial intelligence attitude scale for physicians, along with the path coefficients and t-values from the confirmatory factor analysis of the scale.

Factors	New Item No.		Path Coefficient	Error	t value
Knowledge Dimension	1	I understand the basic principles of artificial intelligence (AI).	0,72	0,49	22,69
	2	I am informed about terms such as machine learning and deep learning.	0,85	0,28	42,13
	3	I know the basic working principles of artificial intelligence algorithms.	0,93	0,14	67,57
	4	I have knowledge about artificial neural networks and their different types.	0,91	0,18	59,69
	5	I understand how I can use artificial intelligence applications in healthcare scenarios.	0,83	0,32	35,30
	6	I am familiar with topics such as data mining and big data analysis.	0,82	0,32	38,65
	7	I know what the terms related to artificial intelligence mean.	0,87	0,25	42,94
Practice Dimension	8	I have advanced training and certifications in artificial intelligence.	0,73	0,47	16,87
	9	I use artificial intelligence-supported diagnosis and diagnostic methods.	0,60	0,64	13,15
	10	I use treatment methods supported by artificial intelligence.	0,68	0,53	15,67
	11	I design/develop websites.	0,77	0,40	22,30
	12	I design/develop mobile applications.	0,79	0,38	19,39
	13	I use programming languages such as R-Project, Phyton.	0,86	0,26	21,05
	14	I contribute to knowledge sharing by organizing artificial intelligence trainings and seminars in the health sector.	0,94	0,12	34,36
	15	I can make strategic plans for the potential of using artificial intelligence in the health sector.	0,92	0,16	35,52
Belief Dimension	16	I believe that artificial intelligence will contribute to being innovative in my profession.	0,74	0,42	22,06
	17	I believe that routine tasks in my field can be performed more effectively with artificial intelligence.	0,85	0,29	34,07
	18	I believe that artificial intelligence will reduce my workload.	0,90	0,20	49,00
	19	Artificial intelligence can improve my professional development.	0,87	0,24	37,42
	20	Artificial intelligence can improve my communication with patients.	0,82	0,33	33,57
	21	Thanks to artificial intelligence, the healthcare system can become more sustainable.	0,95	0,10	76,24
	22	Artificial intelligence can provide a more effective communication environment by strengthening teamwork.	0,89	0,21	37,95
	23	I believe that AI will increase patient-centered care by freeing up more time for health professionals in my field.	0,95	0,10	67,24
	24	I believe that artificial intelligence will provide new opportunities in my field.	0,94	0,11	65,63
	25	I believe that artificial intelligence will break new ground in my field.	0,84	0,30	35,43
	26	I believe AI will help in establishing individualized patient care.	0,87	0,24	37,80

When the loadings of the items of the factor structure were analyzed, it was seen that the factor loadings of the knowledge dimension were 0.72-0.83; the factor loadings of the practice dimension were 0.60-0.94; and the factor loadings of the belief dimension were 0.74-0.95. It can be said that the t values of these factor loadings are all significant (*P*<.001) [13,19]. The path diagram of confirmatory factor analysis is given in Figure-2.

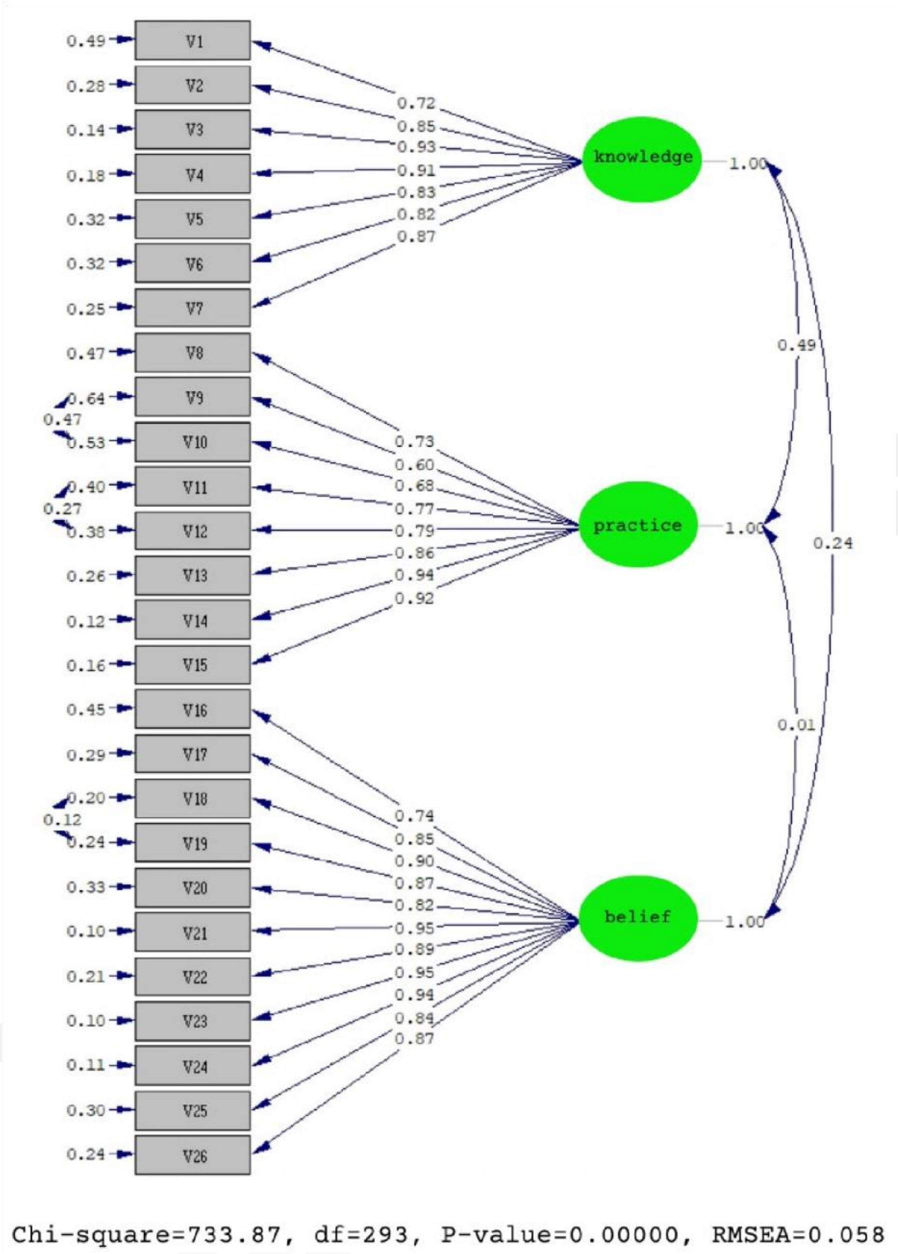

Figure-2. Path Diagram of Attitudes Towards Artificial Intelligence Scale.

Abbreviations: RMSEA, root mean square error of approximation.

In the path diagram of the scale of attitudes towards artificial intelligence, the loadings of the items on the relevant factor and the standard errors of the items (<0.90) show that the scale is compatible with the factor structure. The fit criteria determined in evaluating a factor structure within the scope of the literature, good and acceptable fit values and the evaluation results of the fit values obtained as a result of the analysis are shown in Table 3.

Table-3. Confirmatory factor analysis fit indices for the scale of attitudes toward artificial intelligence

Fit Index*	Good Fit Criterion	Acceptable Fit Criterion	Index Obtained	Result
χ2/sd	0 ≤ χ2/sd ≤ 2,5	2,5<χ2/sd ≤ 5	2,50	Good
RMSEA	.00 ≤ RMSEA ≤ .05	.05 <RMSEA ≤ .08	0,058	Acceptable
SRMR	.00 ≤ SRMR ≤ .05	.05 < SRMR ≤ .10	0,072	Acceptable
CFI	.95 ≤ CFI ≤ 1.00	.90 ≤ CFI < .95	0,99	Good

*Bentler, 1980; Byrne, 2010; Kline, 2011

Abbreviations: χ2, chi-square; sd, standard deviation; RMSEA, root mean square error of approximation; SRMR, standardized root mean squared residual; CFI, comparative fit index.

When the fit values of the factor structure of the scale of attitudes towards artificial intelligence are examined, it can be said that the coefficients obtained are among the criteria recommended in the literature, so the model-data fit is confirmed.

Reliability Results of the Measurement Tool

Cronbach's alpha internal consistency and composite reliability coefficient values of the attitudes towards artificial intelligence scale are shown in Table 4.

Table-4. Alpha Coefficients of the Scale of Attitudes Towards Artificial Intelligence

Sub Factor	Alpha Coefficient	Composite Reliability
Knowledge Dimension	0,93	0,70
Practice Dimension	0,88	0,71
Belief Dimension	0,93	0,86

When the reliability coefficients of the attitudes towards artificial intelligence scale were examined, it was determined that it had a value of 0.93 for the knowledge dimension, 0.88 for the practice dimension and 0.93 for the belief dimension. When the composite reliability coefficients of the scale were examined, it was determined that it had a value of 0.70 for the knowledge dimension, 0.71 for the practice dimension and 0.89 for the belief dimension. Considering that measurements with a reliability coefficient of 0.70 and above are considered reliable [20], it can be said that the calculated reliability coefficients are sufficient.

Artificial Intelligence Attitude Scale

This attitude scale developed for artificial intelligence consists of 26 items (Table-2). The scale has a 5-point Likert-type rating feature. The scale has three sub-factor structures within itself. The first factor knowledge dimension consists of 7 items and the scores that can be obtained from the scale vary between 7-35, the second factor practice dimension consists of 8 items and the scores that can be obtained from the scale vary between 8-40, and the third factor belief dimension consists of 11 items and the scores that can be obtained from the scale vary between 11-55. The higher the scores obtained from these sub-factors, the higher the relevant factor behaviors of the participants.

Descriptive Values of Attitude Towards Artificial Intelligence Subscale Scores

The new scale was implemented on a second sample. At this stage, the final dataset comprised 441 valid observations from a sample of 509 physicians, confirming that, as outlined in the Study Design section, we have attained the minimum participant threshold necessary to accurately represent the physician population in Turkey. The minimum and maximum values, arithmetic mean and standard deviation values of the scores obtained from the participants' attitudes towards artificial intelligence subscales are given in Table 6.

Table-5. Descriptive Values of Attitudes Towards Artificial Intelligence Subscales

Sub Scale	N	Min	Max	X̄±S.S
Knowledge Dimension	441	7,00	35,00	18,71±5,81
Practice Dimension	441	8,00	25,00	11,31±3,71
Belief Dimension	441	11,00	55,00	37,58±9,22

Abbreviations: N, number; Min, minimum; Max, maximum; X̄, mean; S.S, sum of squares.

When the scores obtained from the subscales of attitudes towards artificial intelligence were examined, it was determined that the mean scores of the group in the knowledge dimension (18.71±5.81) and the practice dimension (11.31±3.71) were below the middle level and the mean score in the belief dimension (37.58±9.22) was above the middle level.

Comparison of Attitude Towards Artificial Intelligence Subscale Scores According to Various Independent Variables

The comparison of the mean scores of the knowledge dimension of the attitude towards artificial intelligence subscales according to various independent variables is given in Table 7.

Table-6. Results of knowledge dimension subscale scores according to subgroups of independent variables

Variable	Level	N	X̄±S.S	SD	*t*/F	*P*	η_2	Difference
	>61	34	19,26±5,01					
	1-5	58	17,43±5,38					
	6-10	75	18,48±5,63					
	11-15	78	18,40±6,30					
	16-20	63	18,49±5,42					
	>21	164	19,51±5,87					
	Completed	303	18,77±5,79					
	In progress	61	17,62±5,59					
	None	77	19,36±6,03					
Sex	Female(1)	174	17,43±5,43	439	3,80	**<.001**	0,03	2-1
	Male(2)	267	19,55±5,91					
Active Health Care Delivery	Yes No	413	18,62±5,79	439	1,31	.190	-	-
		28	20,11±6,09					
Age (years)	<30	60	17,33±5,25	4 436	2,31	.057	-	-
	31-40	154	18,29±6,07					
	41-50	107	18,83±5,41					
	51-60	86	20,06±6,29					
Seniority4 **(years)**433					1,61	.172	-	-
Specialization Status1,57				1 438		.209	-	-
Employed Institution	URH(1)	187	18,89±5,34	3 421	3,14	**.025**	0,03	3-2
	Public Hospital(2)	125	17,84±6,05					
	Private Hospital(3)	80	20,13±6,21					
	FHC or CHC (4)	33	17,45±5,77					
Place of Work	Metropolitan District	33	18,76±6,85	3 437	1,21	.305	-	-
	Metropolitan Province	310	18,89±5,59					
	District Center	46	17,17±5,96					
	Province Center	52	19,00±6,25					
Title	Resident(1)	52	16,90±5,49	3 437	7,42	**<.001**	0,05	4-1 4-2
	Specialist(2)	221	18,03±5,64					
	Practitioner(3)	81	19,42±6,00					
	Academician(4)	87	20,87±5,65					
Discipline	Internal Medical Sciences	271	18,34±5,74	2 427	1,80	.166	-	-
	Surgical Medical Sciences	81	19,41±5,58					
	Practitioner	78	19,47±6,16					
Level of Education	Practitioner	78	19,47±6,16	2 432	1,40	.249	-	-
	Specialist	322	18,49±5,71					
	Subspecialist	35	19,69±5,68					

	0	61	17,98±5,79					
	1-20	87	19,68±6,19					
	21-40	68	19,71±6,31	5				
Daily Outpatient Load	41-60	88	18,18±5,91	435	1,75	.121	-	-
	61-80	73	17,64±4,86					
	>81	64	18,98±5,43					
	0	176	18,43±6,09					
	1-5	135	18,74±5,29					
	6-10	42	18,36±5,97	4				
Daily Inpatient Load	11-20	48	19,08±5,31	436	0,54	.704	-	-
	>21	40	19,80±6,74					

Abbreviations: N, number; Min, minimum; Max, maximum; X̄, mean; S.S, sum of squares; SD, standard deviation; η^2, eta squared; URH, university research hospital; FHC, family health center; CHC, commune health center Statistically significant p values are shown in bold.

When the results of the knowledge dimension of the attitude towards artificial intelligence subscales were analyzed, the subscale averages of male physicians (19.55±5.91) were statistically higher than the subscale averages of female physicians (17.43±5.43) (t_{439}=3.80, *P*<.001) and the effect size coefficient (0.03) for this difference was above the small effect size. In the results related to the health institution, the subscale averages of those working in private hospitals (20.13±6.21) were statistically higher than those working in public hospitals (17.84±6.05) ($F_{3,421}$=3.14, *P*=.025) and the effect size coefficient (0.03) for this difference was above the small effect size. The title of physicians also differed statistically significantly Accordingly, academicians (20.87±5.65) had a relatively higher mean ($F_{3,437}$=7.42, *P*=.025) than residents (16.90±5.49) and specialists (18.03±5.64) and the effect size coefficient (0.05) was close to medium effect size.

The comparison of the mean scores of the practice dimension of the attitude towards artificial intelligence subscales according to various independent variables is given in Table-7.

Table-7. Results of practice dimension subscale scores according to subgroups of independent variables

Variable	Level	N	X̄±S.S	SD	*t*/F	*P*	η2	Difference
	>61	34	12,00±3,63					
	1-5	58	11,71±3,96					
	6-10	75	10,85±3,82					
	11-15	78	10,90±3,74					
	16-20	63	10,75±2,98					
	>21	164	11,77±3,73					
	Completed	303	11,26±3,66					
	In progress	61	10,98±3,85					
	None	77	11,75±3,79					
Sex	Female	174	11,17±3,69	439	0,64	.524	-	-
	Male	267	11,40±3,73					
Active Health Care Delivery	Yes No	413	11,24±3,73	439	1,45	.149	-	-
		28	12,29±3,26					
Age (years)	<30	60	11,75±3,79	4 436	2,06	.086	-	-
	31-40	154	10,85±3,81					
	41-50	107	10,95±3,29					
	51-60	86	11,98±3,91					
Seniority4 **(years)**433					1,71	.147	-	-
Specialization Status0,82				1 438		.443	-	-
Employed Institution	URH(1)	187	11,49±3,92	3 421	2,89	**.035**	0,02	3-2
	Public Hospital(2)	125	10,75±3,38					
	Private Hospital(3)	80	12,15±3,84					
	FHC or CHC (4)	33	10,58±3,34					
Place of Work	Metropolitan District	33	10,55±2,84	3 437	2,06	.105	-	-
	Metropolitan Province	310	11,55±3,79					
	District Center	46	10,30±3,45					
	Province Center	52	11,21±3,82					
Title	Resident(1)	52	10,90±3,76	3 437	6,45	**<.001**	0,04	4-1 4-2
	Specialist(2)	221	10,71±3,30					
	Practitioner(3)	81	11,74±3,78					
	Academician(4)	87	12,64±4,23					
Discipline	Internal Medical Sciences	271	11,16±3,82	2 427	1,01	.367	-	-
	Surgical Medical Sciences	81	11,26±3,23					
	Practitioner	78	11,83±3,80					
Level of Education	Practitioner	78	11,83±3,80	2 432	2,79	.063	-	-
	Specialist	322	11,09±3,58					
	Subspecialist	35	12,37±4,62					

Daily Outpatient Load	0	61	11,10±3,56	5				
	1-20	87	11,78±3,64	435	0,70	.627	-	-
	21-40	68	11,49±3,87					
	41-60	88	11,11±3,45					
	61-80	73	11,45±3,97					
	>80	64	10,77±3,85					
Daily Inpatient Load	0(1)	176	11,27±3,60	4				5-3
	1-5(2)	135	11,36±3,60	436	3,23	**.013**	0,03	5-4
	6-10(3)	42	10,67±4,09					
	11-20(4)	48	10,42±2,85					
	>20(5)	40	13,03±4,55					

Abbreviations: N, number; Min, minimum; Max, maximum; X̄, mean; S.S, sum of squares; SD, standard deviation; η², eta squared; URH, university research hospital; FHC, family health center; CHC, commune health center Statistically significant p values are shown in bold.

When the results of the practice dimension of the attitude towards artificial intelligence subscales were analyzed, private hospital employees (12,15±3,84) had a statistically higher mean ($F_{3,421}$=2,89, *P*=.035) compared to those working in public hospitals (10,75±3,38) and the effect size coefficient (0,02) was above the small effect size. Again, academicians (12.64±4.23) had statistically higher mean scores than residents (10.90±3.76) and specialists (10.71±3.30) ($F_{3,437}$=6.45, *P*<.001) and the effect size coefficient (0.04) was close to medium effect size.

The comparison of the mean scores of the belief dimension of the attitude subscales towards artificial intelligence according to various independent variables is given in Table-8.

Table-8. Results of belief dimension subscale scores according to subgroups of independent variables.

Variable	Level	N	X̄±S.S	SD	*t/F*	*P*	η2	Difference
Sex	Female	174	36,97±3,69	439	1,14	.257	-	-
	Male	267	37,99±3,73					
Active Health Care Delivery	Yes	413	37,50±3,73	439	0,76	.451	-	-
	No	28	38,86±3,26					
Age (years)	<30	60	39,33±3,79	4 436	0,92	.455	-	-
	31-40	154	37,23±3,81					
	41-50	107	36,79±3,29					
	51-60	86	37,55±3,91					
	>61	34	38,68±3,63					
Seniority (years)	1-5	58	39,64±3,96	4 433	1,97	.098	-	-
	6-10	75	35,92±3,82					
	11-15	78	39,00±3,74					
	16-20	63	36,78±2,98					
	>21	164	37,25±3,73					
Specialization Status	Completed	303	37,15±3,66	1 438	1,20	.302	-	-
	In progress	61	39,00±3,85					
	None	77	38,16±3,79					
Employed Institution	URH(1)	187	38,03±3,92	3 421	4,54	**.004**	0,03	3-2
	Public Hospital(2)	125	35,42±3,38					
	Private Hospital(3)	80	40,00±3,84					
	FHC or CHC (4)	33	38,58±3,34					
Place of Work	Metropolitan District	33	36,27±2,84	3 437	0,31	.818	-	-
	Metropolitan Province	310	37,69±3,79					
	District Center	46	38,15±3,45					
	Province Center	52	37,29±3,82					
Title	Resident	52	38,79±3,76	3 437	1,02	.383	-	-
	Specialist	221	36,87±3,30					
	Practitioner	81	38,49±3,78					
	Academician	87	37,83±4,23					
Discipline	Internal Medical Sciences	271	37,52±3,82	2 427	0,50	.605	-	-
	Surgical Medical Sciences	81	37,21±3,23					
	Practitioner	78	38,58±3,80					
Level of Education	Practitioner	78	38,58±3,80	2 432	1,39	.249	-	-
	Specialist	322	37,20±3,58					
	Subspecialist	35	39,40±4,62					

	0	61	35,93±3,56					
	1-20	87	38,16±3,64					
	21-40	68	38,71±3,87	5				
Daily Outpatient Load	41-60	88	37,41±3,45	435	0,71	.620	-	-
	61-80	73	37,18±3,97					
	>81	64	37,88±3,85					
	0	176	38,35±3,60					
	1-5	135	36,79±3,60					
	6-10	42	35,26±4,09	4				
Daily Inpatient Load	11-20	48	37,88±2,85	436	1,47	.209	-	-
	>21	40	39,00±4,55					

Abbreviations: N, number; Min, minimum; Max, maximum; X̄, mean; S.S, sum of squares; SD, standard deviation; η², eta squared; URH, university research hospital; FHC, family health center; CHC, commune health center Statistically significant p values are shown in bold.

When the results of the belief dimension, one of the subscales of attitudes towards artificial intelligence, were examined, a statistical difference was observed only between health institutions.

Accordingly, physicians working in private hospitals (40.00±3.84) had a statistically higher mean ($F_{3,421}$=4.54, *P*=.004) compared to physicians working in public hospitals (35.42±3.38) and the effect size coefficient (0.03) was above the small effect size.

Discussion

Principal Results

The rapid adoption of artificial intelligence (AI) in the healthcare sector makes it imperative to evaluate the attitudes of healthcare professionals towards these technologies. At this point, we believe that our study is the first scale to assess physicians' attitudes towards artificial intelligence independent of specific medical specialties, titles, classes, or medical subjects.

It's noteworthy that literature primarily consists of questionnaires, rather than developing scales specifically related to artificial intelligence for physicians. To give examples, Oh et al. A questionnaire evaluated the confidence of physicians or physician candidates in artificial intelligence among 669 participants, 386 of whom were physicians, including medical students [21]. Alkhatieb and Subke conducted a survey study on physicians' attitudes toward artificial intelligence with 205 physicians [22].

The Artificial Intelligence Attitude Scale (AIAS), which was developed in our study and consists of three sub-dimensions, provides a tool for this need. The findings show that there are significant differences in health workers' beliefs, knowledge and attitudes towards implementation of AI. The reliability and validity of the scale is in line with the criteria suggested in the literature and is an important start for understanding the impacts of AI in the healthcare system.

In recent years, studies on the impact of AI in health services show that the interest in the technology is increasing rapidly [23]. High scores, especially in the belief subscale, indicate that healthcare professionals perceive AI positively in general. For example, Davenport and Kalakota's study found that AI is seen as an important tool for improving the efficiency of healthcare professionals [24]. However, low implementation scores indicate that there are still challenges to the adoption of this technology in the field [25].

It was observed that male health workers scored higher on the knowledge dimension compared to females. This is in line with previous studies suggesting that men are more prone to technological innovations [26–28]. However, female employees scored similarly on the practice dimension, suggesting that gender differences are more concentrated in the processes of information access and evaluation. In addition, female physicians scored positively higher on the educational subscales of other scales related to physicians [29,30]. This finding emphasizes the need to pay attention to gender-based differences for a more inclusive adoption of AI.

The higher scores of private hospital employees in the belief and implementation sub-dimensions can be explained by the earlier and more effective adoption of AI technologies by these organizations [31]. Moreover, Leeuwen et al. underline that this may be related to budget constraints in the public sector [32]. The lower scores in public hospitals may be related to lack of resources and organizational constraints [33].

It was observed that experienced health workers had higher scores in the knowledge and practice sub-dimensions. This can be interpreted as the effect of being exposed to technological developments over many years. However, it is understood from the results in the belief sub-dimension that young employees exhibit a more idealistic perspective towards AI. Topol's (2019) study shows that young healthcare workers can adopt technology faster and have innovative perspectives [34].

It is noteworthy that academics have higher knowledge scores in our study. Academic settings seem to be advantageous in terms of access to knowledge and openness to innovations [35]. However, the lower adoption of AI applications in surgical specialty may be associated with technical difficulties and adaptation processes [36].

This study was conducted with a large national sample and provided comprehensive analyses. The three sub-dimensional structure of the scale provides the opportunity to assess different aspects of attitudes towards AI separately.

Limitations

The limitations of the study include its cross-sectional design and the fact that it is limited to Turkey sample only. In the future, it would be useful to compare attitudes towards AI in different countries and cultural contexts. In addition, longitudinal studies examining the change in attitudes towards AI over time can increase the knowledge in this field.

Conclusion

The Artificial Intelligence Attitude Scale for Physicians developed in this study was evaluated as a reliable and valid instrument to measure the belief, knowledge and practice dimensions of healthcare professionals towards artificial intelligence in three sub-factors. The findings show that healthcare professionals have a positive attitude towards AI in general, but there is limited adoption in practical applications. In particular, male, experienced doctors and academicians have higher scores in the knowledge dimension, indicating that these groups may adopt the technology more easily. However, heavy workload and not working in a private hospital stand out as important barriers to the integration of AI. These findings highlight the need for targeted training programs and infrastructure improvements to increase awareness and facilitate adoption of AI in the healthcare sector. In future studies, longitudinal designs and similar analyses in different cultural contexts will contribute to a more comprehensive understanding of attitudes towards AI. Additionally, let us state the following, we anticipate that the adaptability of this scale will allow it to effectively capture the opinions of other healthcare workers, such as nurses and administrative assistants, regarding artificial intelligence.

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Authors' Contributions

Özbilen M, Özdede M, Polat ZP, Zorlu Görgülügil G and Tezci İH conceptualized the study and designed the methodology. Polat ZP provided checks and feedbacks throughout the entire phase of the study. Özdede M and Zorlu Görgülügil G provided the distribution of the questionnaire and scale web links to the participants. Özbilen M collected the survey data from participants. Tezci İH performed the statistical analysis and interpreted the results. Özbilen M wrote the initial draft of the manuscript. All authors reviewed and revised the manuscript. Tezci İH prepared all the figures and tables. Özbilen M facilitated ethical approval and managed administrative procedures. All authors reviewed and approved the final manuscript.

Conflict of Interest

We have no conflicting financial interests to report.

Abbreviations

AI	Artificial intelligence
AIAS	Artificial intelligence attitude scale
CFA	Confirmatory factor analysis
CFI	Comparative fit index
CHC	Commune health center
DAHUDER	Turkish College of Internal Medicine
EFA	Exploratory factor analysis
FHC	Family health center
RMSEA	Root mean square error of approximation
SD	Standard deviation
SRMR	Standardized root mean squared residual
SS	Sum of squares
URH	University research hospital
$\bar{X}$	Mean
η^2	Eta squared

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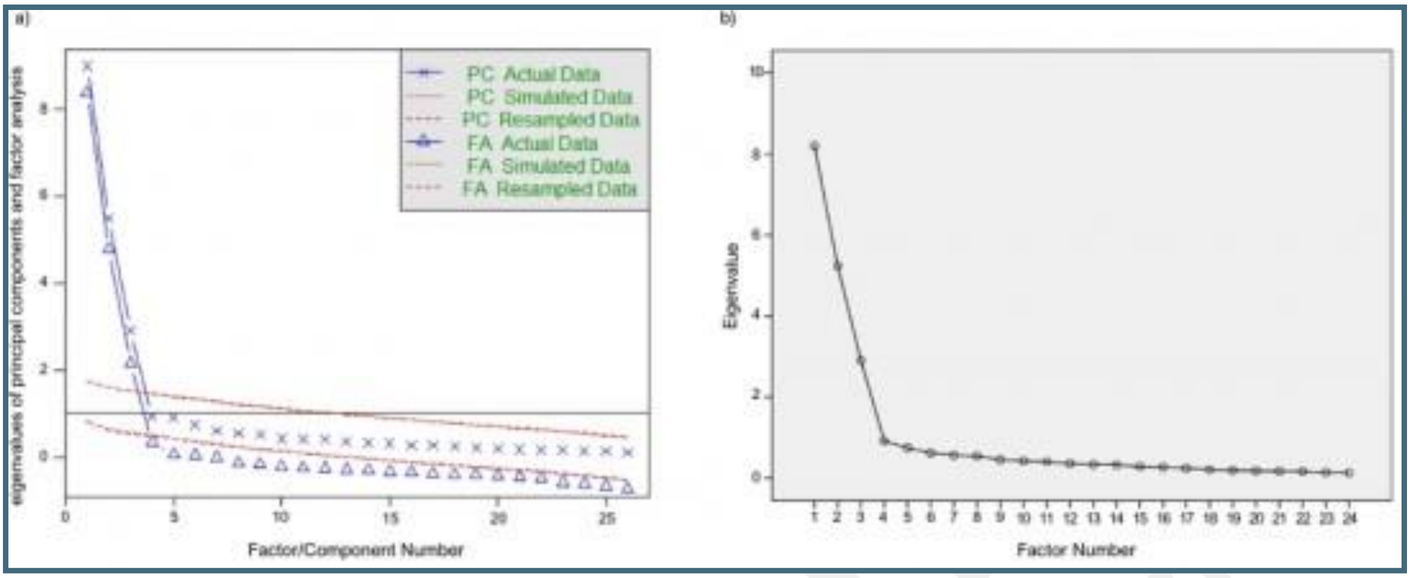
Supplementary Files

Figures

Graphs obtained from exploratory factor analysis: (a) parallel analysis eigenvalue graph and (b) slope-accumulation graph.



Path diagram of attitudes towards artificial intelligence scale. Abbreviations: RMSEA, root mean square error of approximation.