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Artificial Intelligence in Health

ORIGINAL RESEARCH ARTICLE

# Perceived barriers to artificial intelligence integration among Moroccan public health care professionals: A cross-sectional study

## Supplementary File

**Table S1. Bonferroni-adjusted Dunn's post hoc pairwise comparisons of perceived artificial intelligence barrier scores**

| Participant characteristic | Barrier dimension | Pairwise comparison | Group with higher score | Adjusted *p*-value |
|---|---|---|---|---|
| Age group | Technological | 21–34 years vs. ≥55 years | ≥55 years | < 0.001 |
| | | 35–44 years vs. ≥55 years | ≥55 years | 0.005 |
| | Ethical and personal | 21–34 years vs. 45–54 years | 45–54 years | 0.011 |
| | | 21–34 years vs. ≥55 years | ≥55 years | 0.004 |
| | Overall barriers | 21–34 years vs. 45–54 years | 45–54 years | 0.019 |
| | | 21–34 years vs. ≥55 years | ≥55 years | <0.001 |
| | | 35–44 years vs. ≥55 years | ≥55 years | 0.023 |
| Years of professional experience | Technological | <1 year vs. >20 years | >20 years | 0.042 |
| | | 1–5 years vs. >20 years | >20 years | <0.001 |
| | | 6–10 years vs. >20 years | >20 years | 0.018 |
| | Ethical and personal | 1–5 years vs. >20 years | >20 years | 0.003 |
| | Overall barriers | <1 year vs. >20 years | >20 years | 0.039 |
| | | 1–5 years vs. >20 years | >20 years | <0.001 |
| Professional category | Technological | Medical staff vs. nursing staff | Medical staff | 0.002 |
| | | Medical staff vs. health technicians | Medical staff | <0.001 |
| | Organizational | Medical staff vs. health technicians | Medical staff | <0.001 |
| | | Medical staff vs. administrative staff | Medical staff | 0.041 |
| | | Nursing staff vs. health technicians | Nursing staff | 0.044 |
| | Ethical and personal | Medical staff vs. health technicians | Medical staff | <0.001 |
| | | Medical staff vs. educators and trainers | Medical staff | 0.002 |
| | Overall barriers | Medical staff vs. nursing staff | Medical staff | 0.003 |
| | | Medical staff vs. health technicians | Medical staff | <0.001 |
| | | Medical staff vs. educators and trainers | Medical staff | 0.004 |
| | | Nursing staff vs. health technicians | Nursing staff | 0.009 |

(*Cont'd...*)

**Table S1.** (***Continued***)

| Participant characteristic | Barrier dimension | Pairwise comparison | Group with higher score | Adjusted *p*-value |
|---|---|---|---|---|
| Highest educational qualification | Technological | Bachelor's degree in nursing vs. medical doctorate | Medical doctorate | <0.001 |
| | | Master's degree in health sciences vs. medical doctorate | Medical doctorate | 0.035 |
| | | PhD in health sciences vs. medical doctorate | Medical doctorate | 0.003 |
| | | Medical doctorate vs. other qualification | Medical doctorate | 0.023 |
| | Organizational | Bachelor's degree in nursing vs. medical doctorate | Medical doctorate | 0.031 |
| | | Medical doctorate vs. other qualification | Medical doctorate | 0.009 |
| | Ethical and personal | Bachelor's degree in nursing vs. master's degree in health sciences | Bachelor's degree in nursing | 0.040 |
| | | Master's degree in health sciences vs. medical doctorate | Medical doctorate | <0.001 |
| | Interdisciplinary collaboration | Master's degree in health sciences vs. other qualification | Other qualification | 0.016 |
| | Overall barriers | Bachelor's degree in nursing vs. medical doctorate | Medical doctorate | <0.001 |
| | | Master's degree in health sciences vs. medical doctorate | Medical doctorate | <0.001 |
| | | PhD in health sciences vs. medical doctorate | Medical doctorate | 0.007 |
| | | Medical doctorate vs. other qualification | Medical doctorate | 0.042 |
| Department/unit | Organizational | Medical-surgical department vs. other departments | Medical-surgical department | 0.007 |
| | | Primary health care facility vs. other departments | Primary health care facility | 0.001 |
| | Ethical and personal | Emergency department vs. primary health care facility | Primary health care facility | 0.030 |
| | | Primary health care facility vs. other departments | Primary health care facility | <0.001 |
| | Overall barriers | Primary health care facility vs. other departments | Primary health care facility | 0.012 |

Notes: Only statistically significant pairwise comparisons after Bonferroni adjustment are shown. The "Group with higher score" column indicates which group reported the higher perceived barrier score in each comparison. *p*-values are adjusted for multiple comparisons.

**Table S2. Model diagnostics, robust and bootstrap estimates for the five general linear models (*N* = 480)**

| Model | Shapiro–Wilk *W* (*p*) | Skewness/kurtosis | Breusch–Pagan *p* | Max Cook's *D* | HC3 *F* for prior artificial intelligence training (p) | B for prior artificial intelligence training (bootstrap 95% confidence interval) |
|---|---|---|---|---|---|---|
| Technological | 0.995 (0.152) | 0.09/−0.36 | 0.090 | 0.032 | 19.31 (< 0.001) | −0.37 (−0.53, −0.20) |
| Organizational | 0.994 (0.058) | −0.01/−0.12 | 0.018 | 0.041 | 187.98 (< 0.001) | −1.22 (−1.39, −1.04) |
| Ethical and personal | 0.989 (0.002) | 0.31/−0.18 | <0.001 | 0.068 | 11.74 (0.001) | −0.40 (−0.63, −0.17) |
| Interdisciplinary collaboration | 0.972 (<0.001) | 0.62/0.67 | 0.008 | 0.080 | 21.45 (< 0.001) | −0.43 (−0.61, −0.26) |
| Overall barriers | 0.994 (0.052) | 0.22/0.31 | 0.001 | 0.094 | 89.92 (< 0.001) | −0.62 (−0.74, −0.50) |

Notes: All models comprised 25 numerator and 454 denominator degrees of freedom. Bootstrap estimates are based on 1,000 resamples using the percentile method. Generalized variance inflation factors ($GVIF^{1/(2df)}$) ranged from 1.07 to 1.68 across all predictors and models. The maximum leverage value was 0.50, attributable to the two participants in the other professionals category. HC3 = Heteroscedasticity-consistent covariance estimator; *B* = Unstandardized regression coefficient.

**Table S3. Unstandardized parameter estimates (*B*) with 95% confidence intervals from the five multivariable general linear models (*N* = 480)**

| Predictor (reference category) | Technological | Organizational | Ethical and personal | Interdisciplinary collaboration | Overall |
|---|---|---|---|---|---|
| Gender (ref. Male) | | | | | |
| Female | +0.03 (−0.13, +0.19) | −0.00 (−0.15, +0.15) | +0.00 (−0.21, +0.22) | −0.09 (−0.29, +0.11) | −0.01 (−0.13, +0.12) |
| Age group (ref. 21–34 years) | | | | | |
| 35–44 years | +0.23 (−0.05, +0.50) | +0.05 (−0.20, +0.31) | +0.30 (−0.06, +0.66) | +0.18 (−0.15, +0.52) | +0.18 (−0.03, +0.40) |
| 45–54 years | +0.23 (−0.14, +0.60) | +0.08 (−0.27, +0.42) | +0.32 (−0.17, +0.80) | −0.10 (−0.55, +0.35) | +0.14 (−0.15, +0.43) |
| ≥ 55 years | +0.77 (+0.23, +1.31) * | −0.18 (−0.68, +0.32) | +0.76 (+0.05, +1.47) * | +0.39 (−0.27, +1.05) | +0.44 (+0.02, +0.86) * |
| Professional experience (ref. < 1 year) | | | | | |
| 1–5 years | −0.11 (−0.29, +0.08) | −0.04 (−0.22, +0.13) | −0.19 (−0.43, +0.05) | −0.20 (−0.42, +0.03) | −0.12 (−0.27, +0.02) |
| 6–10 years | −0.15 (−0.41, +0.11) | −0.07 (−0.31, +0.17) | +0.10 (−0.24, +0.43) | +0.01 (−0.31, +0.32) | −0.05 (−0.26, +0.15) |
| 11–20 years | −0.19 (−0.52, +0.14) | −0.13 (−0.44, +0.17) | −0.15 (−0.58, +0.29) | −0.19 (−0.59, +0.22) | −0.17 (−0.42, +0.09) |
| > 20 years | −0.02 (−0.42, +0.39) | +0.27 (−0.11, +0.65) | +0.07 (−0.47, +0.60) | −0.14 (−0.63, +0.36) | +0.05 (−0.26, +0.37) |
| Professional category (ref. Medical staff) | | | | | |
| Nursing staff | +0.89 (+0.00, +1.79) * | +0.39 (−0.44, +1.22) | +0.05 (−1.12, +1.21) | −0.24 (−1.33, +0.84) | +0.40 (−0.31, +1.10) |
| Health technicians | +0.55 (−0.39, +1.49) | −0.00 (−0.88, +0.88) | −0.09 (−1.32, +1.14) | −0.77 (−1.92, +0.37) | +0.04 (−0.69, +0.78) |
| Administrative staff | +0.38 (−0.61, +1.37) | −0.02 (−0.94, +0.91) | +0.35 (−0.94, +1.65) | −0.32 (−1.53, +0.89) | +0.14 (−0.64, +0.92) |
| Educators and trainers | +0.62 (−0.28, +1.52) | +0.42 (−0.42, +1.26) | −0.39 (−1.57, +0.78) | −0.73 (−1.82, +0.37) | +0.14 (−0.57, +0.84) |

(*Cont'd...*)

**Table S3. (*Continued*)**

| Predictor (reference category) | Technological | Organizational | Ethical and personal | Interdisciplinary collaboration | Overall |
|---|---|---|---|---|---|
| Other professionals | +1.08 (−0.27, +2.42) | +1.03 (−0.22, +2.29) | −0.82 (−2.58, +0.94) | −1.05 (−2.69, +0.58) | +0.33 (−0.72, +1.39) |
| Educational qualification (ref. Bachelor's degree in nursing) | | | | | |
| Master's degree in health sciences | +0.14 (−0.08, +0.35) | +0.10 (−0.10, +0.30) | −0.39 (−0.67, −0.12) * | −0.14 (−0.40, +0.12) | −0.02 (−0.19, +0.15) |
| PhD in health sciences | −0.03 (−0.45, +0.38) | −0.11 (−0.50, +0.27) | −0.05 (−0.60, +0.49) | +0.23 (−0.28, +0.74) | −0.01 (−0.34, +0.32) |
| Medical doctorate | +1.14 (+0.24, +2.05) * | +0.54 (−0.30, +1.39) | +0.13 (−1.05, +1.32) | −0.15 (−1.26, +0.95) | +0.56 (−0.15, +1.27) |
| Other qualification | +0.13 (−0.31, +0.58) | +0.20 (−0.21, +0.62) | −0.36 (−0.94, +0.23) | +0.80 (+0.25, +1.34) * | +0.18 (−0.17, +0.53) |
| Department/unit (ref. Medical-surgical) | | | | | |
| Intensive care unit | +0.20 (−0.21, +0.61) | −0.17 (−0.54, +0.21) | −0.42 (−0.95, +0.11) | −0.47 (−0.97, +0.02) | −0.14 (−0.45, +0.18) |
| Emergency department | +0.11 (−0.18, +0.40) | −0.40 (−0.66, −0.13) * | −0.30 (−0.67, +0.08) | −0.08 (−0.43, +0.27) | −0.14 (−0.36, +0.09) |
| Mother and child health department | +0.01 (−0.28, +0.29) | −0.28 (−0.55, −0.01) * | +0.09 (−0.28, +0.47) | −0.08 (−0.42, +0.27) | −0.07 (−0.30, +0.15) |
| Medical technology department | +0.05 (−0.36, +0.45) | −0.34 (−0.72, +0.04) | −0.37 (−0.90, +0.16) | −0.14 (−0.63, +0.35) | −0.17 (−0.49, +0.15) |
| Rehabilitation | +0.07 (−0.52, +0.66) | −0.46 (−1.01, +0.09) | −0.12 (−0.90, +0.65) | +0.47 (−0.25, +1.19) | −0.04 (−0.50, +0.43) |
| Primary health care facility | +0.25 (+0.01, +0.49) * | −0.10 (−0.33, +0.12) | +0.24 (−0.08, +0.55) | +0.07 (−0.23, +0.36) | +0.12 (−0.07, +0.31) |
| Other department | +0.22 (−0.04, +0.47) | −0.30 (−0.53, −0.06) * | +0.03 (−0.30, +0.36) | +0.18 (−0.12, +0.49) | +0.04 (−0.16, +0.23) |
| Prior formal AI training (ref. No training) | | | | | |
| Prior formal AI training | −0.37 (−0.54, −0.19) * | −1.22 (−1.38, −1.06) * | −0.40 (−0.62, −0.17) * | −0.43 (−0.64, −0.21) * | −0.62 (−0.75, −0.48) * |

Notes: *B* = Unstandardized regression coefficient from the general linear model, mutually adjusted for all seven predictors; values in parentheses are 95% confidence intervals. An asterisk indicates $p < 0.05$. Positive values indicate higher perceived barriers relative to the reference category. Each model comprised 25 numerator and 454 denominator degrees of freedom. Reference categories are given in parentheses in the first column.

**Table S4. Sensitivity analyses of the association between prior formal artificial intelligence training and perceived barriers (*N* = 480)**

| Analysis | Outcome | *F* | *p* | $\eta_p^2$ | Adjusted $R^2$ |
|---|---|---|---|---|---|
| Primary model | Organizational barriers (3 items) | 219.15 | <0.001 | 0.326 | 0.382 |
| Primary model | Overall barriers (11 items) | 79.03 | <0.001 | 0.148 | 0.240 |
| Sparse categories pooled | Organizational barriers (3 items) | 225.02 | <0.001 | 0.330 | 0.380 |
| Sparse categories pooled | Overall barriers (11 items) | 79.12 | <0.001 | 0.148 | 0.243 |
| Overlapping training item removed | Organizational barriers (2 items) | 43.92 | <0.001 | 0.088 | 0.156 |
| Overlapping training item removed | Overall barriers (10 items) | 38.14 | <0.001 | 0.078 | 0.176 |

Notes: All models were mutually adjusted for gender, age group, years of professional experience, professional category, highest educational qualification, department/unit, and prior formal AI training. In the pooling analysis, other professionals ($n = 2$) were merged with administrative staff ($n = 13$), the intensive care unit ($n = 16$) with the medical-surgical department ($n = 48$), and rehabilitation ($n = 7$) with the medico-technical department ($n = 21$); these models comprised 22 numerator and 457 denominator degrees of freedom. In the item-removal analysis, the item "No formal training received on AI technologies" was excluded from the organizational and overall scores. Adjusted regression coefficients for prior formal AI training in the item-removal models were $B = -0.77$ (95% CI −1.00 to −0.54) for organizational barriers and $B = -0.47$ (95% CI −0.61 to −0.32) for overall barriers. $\eta_p^2$ = partial eta squared.

**Table S5. Exploratory factor analysis of the 11 retained items: Principal axis factoring with Promax rotation, four-factor solution (*N* = 480)**

| Item | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|---|---|---|---|---|
| Lack of familiarity with the concept of AI in health care | −0.12 | −0.02 | 0.81[a] | −0.10 |
| Limited ease of use of digital technologies in daily practice | 0.09 | −0.11 | 0.72[a] | 0.13 |
| Insufficient access to the digital tools required at the workplace | 0.05 | 0.18 | −0.04 | 0.64[a] |
| Current infrastructure does not support AI integration | −0.19 | 0.56[a] | 0.05 | 0.19 |
| Lack of managerial support for adopting new technologies | 0.01 | 0.91[a] | −0.20 | −0.04 |
| No formal training received on AI technologies | 0.05 | 0.35[a] | 0.04 | −0.03 |
| Lack of clarity of institutional policies and procedures on AI | 0.09 | 0.56[a] | 0.04 | 0.11 |
| Discomfort with AI taking over certain aspects of care | 0.63[a] | 0.14 | 0.07 | −0.03 |
| Lack of confidence in AI for making clinical decisions | 0.37[a] | 0.16 | 0.21 | −0.10 |
| Ineffective interdisciplinary collaboration during AI integration | 0.94[a] | −0.04 | −0.15 | −0.08 |
| Insufficient interprofessional communication for AI implementation | 0.55[a] | −0.13 | −0.02 | 0.19 |
| Explained variance (%) | 16.4 | 15.3 | 11.8 | 4.9 |

Notes: Cumulative explained variance: 48.4%. Eigenvalues of the unrotated solution: 3.58, 1.64, 1.09, 0.91, 0.82, 0.69, 0.56, 0.49, 0.45, 0.40, 0.36. Parallel analysis based on 500 simulated datasets supported the retention of two factors, whereas the Kaiser criterion supported three. Inter-factor correlations ranged from 0.20 to 0.58. [a]Loadings of 0.35 or above. Items are presented reverse-scored, so that higher values indicate greater perceived barriers.