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Digital Competence of Medical Personnel: A Systematic Literature Review and Meta-Analysis

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Abstract

Digital competence among healthcare professionals has become increasingly essential for ensuring high-quality patient care and adapting to the rapid advancement of healthcare technologies. Therefore, this systematic review and meta-analysis aimed to synthesize existing evidence regarding digital competence levels among healthcare professionals, identify the key factors associated with digital competence, and evaluate the effectiveness of digital competence training interventions. A comprehensive search of PubMed, Scopus, Web of Science, and ERIC databases was conducted for studies published between January 2015 and December 2023. Observational and quasi-experimental studies involving physicians, nurses, and other healthcare professionals were included, with screening, data extraction, and risk-of-bias assessment independently performed by two reviewers using the Newcastle-Ottawa Scale. Meta-analysis was conducted using a random-effects model. A total of 47 studies involving 12,356 participants from 28 countries met the inclusion criteria. The pooled mean digital competence score was 68.2% (95% CI: 64.8–71.6%), with significant differences observed across professional groups and healthcare settings. Physicians demonstrated higher competence levels (71.4%) than nurses (66.3%) ($p = 0.003$), while healthcare personnel working in tertiary hospitals showed greater competence (72.1%) compared with those in primary care settings (61.5%) ($p < 0.001$). Important predictors of digital competence included age, years of professional experience, and formal information technology training. Furthermore, digital competence training interventions significantly improved competence levels by 18.5% (95% CI: 14.2–22.8%; $I^2 = 58\%$). Overall, the quality of evidence was moderate for most outcomes, indicating that targeted training programs can play a substantial role in enhancing digital competence among healthcare professionals.

Keywords Digital Competence; Digital Literacy; Healthcare Professionals; Meta-Analysis; Medical Personnel

INTRODUCTION

Digital transformation in healthcare has accelerated dramatically over the past decade, fundamentally reshaping clinical practice, patient engagement, and healthcare administration. The integration of electronic health records (EHRs), telemedicine,

artificial intelligence-assisted diagnostics, and mobile health applications has become standard practice in many healthcare systems worldwide. This digital revolution necessitates that medical personnel possess adequate digital competencies to effectively utilize these technologies and provide safe, efficient, and patient-centered care (Topol, 2019; World Health Organization, 2021).

Digital competence in healthcare refers to the integrated set of knowledge, skills, attitudes, and values required to effectively use digital technologies and information systems in clinical practice. This encompasses not only technical proficiency but also critical thinking regarding digital tools, information management, cybersecurity awareness, ethical use of data, and the capacity to continuously adapt to emerging technologies. Nevertheless, considerable heterogeneity exists in the assessment, conceptualization, and levels of digital competence among healthcare professionals across different countries and healthcare contexts (Ferrari, 2013; European Commission, 2022).

Emerging evidence suggests that inadequate digital competence represents a substantial barrier to healthcare innovation, quality improvement, and patient safety. Several studies have documented variations in digital competence according to age, professional discipline, geographic region, educational background, and access to training opportunities. These disparities have important implications for healthcare equity, patient safety, implementation fidelity of digital health initiatives, and overall clinical outcomes, particularly as healthcare systems increasingly rely on digital infrastructures and data-driven decision-making processes (Konttila et al., 2019; van Houwelingen et al., 2016).

While numerous interventions aimed at improving digital competence have been implemented in healthcare settings, evidence regarding their effectiveness remains fragmented. Educational programs, professional development workshops, simulation-based learning, and e-health training initiatives have demonstrated varying degrees of success in enhancing digital skills among healthcare professionals. Previous narrative reviews have highlighted the complexity of digital competence development; however, they generally lack quantitative synthesis of intervention outcomes and rigorous evaluation of the quality of evidence available in the literature (Heponiemi et al., 2018; Skiba, 2017).

This systematic review and meta-analysis aimed to: (1) synthesize evidence regarding the prevalence and levels of digital competence among medical personnel globally; (2) identify factors associated with digital competence; (3) evaluate the effectiveness of interventions designed to improve digital competence; and (4) assess

the overall quality of evidence while identifying research gaps to guide future investigations and evidence-based practice in healthcare digitalization (Page et al., 2021).

METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure methodological rigor and transparency throughout the review process. A comprehensive literature search was performed across four major electronic databases PubMed (via MEDLINE), Scopus, Web of Science, and ERIC (Education Resources Information Center) covering studies published between January 1, 2015, and December 31, 2023. The search strategy incorporated a combination of keywords and controlled vocabulary terms related to digital competence, including "digital competence," "digital literacy," "eHealth literacy," and "digital skills," combined with healthcare-related terms such as "healthcare professionals," "physicians," "nurses," and "medical personnel." Studies were eligible for inclusion if they reported original data on digital competence among medical professionals, employed quantitative, qualitative, or mixed-methods designs, were published in peer-reviewed journals from 2015 onward, and provided measurable competence outcomes. Studies focusing exclusively on students, opinion articles, editorials, studies lacking quantitative competence data, and conference abstracts without full-text publications were excluded. Two independent reviewers conducted the screening of titles, abstracts, and full-text articles according to predefined eligibility criteria, with inter-rater reliability assessed using Cohen's kappa coefficient. Data extraction was performed using a standardized form designed to collect information on study characteristics, participant demographics, methods used to assess digital competence, and reported outcomes. The complete search strategies for each database are provided in Supplementary Appendix A.

FINDINGS AND DISCUSSION

Study Selection

The systematic database searches identified 4,826 unique citations. After deduplication, 3,684 articles underwent screening. Full-text assessment was conducted on 153 studies. Forty-seven studies met inclusion criteria. Inter-rater reliability was excellent (Cohen's kappa = 0.87-0.89). A PRISMA flow diagram is presented in Figure 1.

Study Characteristics

The 47 included studies were conducted across 28 countries with a combined sample of 12,356 healthcare professionals. Most were cross-sectional surveys (66%). Participants included physicians (50.4%), nurses (33.6%), and other professionals (15.9%).

Table 1. Study Characteristics (sample)

Study	Country	Design	N	Participants	Mean %	RoB	Ref
Brown et al., 2023	USA	CS	245	Physicians	72.5	Low	1
Chen et al., 2023	China	QE	186	Nurses	65.3	Mod	2
López et al., 2022	Spain	CS	342	Mixed	68.9	Low	3

Overall Digital Competence Levels

Twenty-eight studies reported digital competence suitable for meta-analysis. The pooled mean was 68.2% (95% CI: 64.8-71.6%), with substantial heterogeneity ($I^2 = 71\%$). Competence in developed countries (71.4%) was significantly higher than in developing countries (61.3%, $p = 0.002$). Approximately 58.3% demonstrated adequate competence.

Competence by Professional Category

Physicians showed highest competence (71.4%), followed by nurses (66.3%, difference 5.1%, $p = 0.010$), and other professionals (68.7%).

Competence by Work Setting.

Tertiary hospitals:

1. 72.1%, Mixed settings:
2. 68.9%, Primary care:
3. 61.5% ($p<0.001$).

The difference between tertiary and primary care was substantial at 10.6 percentage points.

Factors Associated with Digital Competence

Meta-regression analyses identified significant predictors:

1. Age: Inverse ($\beta = -0.28$ per 10 years, $p < 0.001$)
2. Experience: Inverse ($\beta = -0.31$ per 10 years, $p < 0.001$)
3. Formal IT training: Positive ($\beta = 0.82$, $p < 0.001$)
4. Self-efficacy: Positive ($\beta = 0.71$, $p < 0.001$)
5. Education: Modest positive ($\beta = 0.18$, $p = 0.012$)

Eight intervention studies showed training improved competence by 18.5% (95% CI: 14.2-22.8%, $I^2 = 58\%$). However, only 2 studies provided 6-month follow-up, showing 28% skill decay, indicating limited long-term sustainability.

55.3% of studies had low risk of bias, 34.0% moderate, 10.6% high risk. Common

limitations included inadequate response rate reporting (44.7%), non-respondent description (38.3%), and unclear sampling (25.5%).

Egger's test suggested minimal publication bias ($p = 0.076$). Trim-and-fill analysis estimated 3 missing studies; adjusted estimate was 66.4%.

Discussion

This review of 47 international studies reveals: (1) moderate mean digital competence (68.2%) with high variability; (2) 40% lack adequate competence; (3) significant profession and setting differences; (4) age and experience inversely predict competence; (5) formal training strongly improves competence; (6) training yields 18.5% improvement but limited sustainability.

The global variation reflects infrastructural disparities. The 'digital age divide' ($\beta = -0.28$ per 10 years) is concerning. The strong association with formal training ($\beta = 0.82$) and 35% untrained rate represents a missed opportunity. Intervention effectiveness (18.5% improvement) is promising, but sparse follow-up data with 28% decay at 6 months raises sustainability questions.

GRADE assessment yielded moderate quality for most outcomes. Evidence for long-term sustainability is low. Stronger prospective cohort studies and RCTs with standardized measures and 12+ month follow-up are needed.

Clinical and Policy Implications

1. Universal baseline competence assessment in healthcare organizations.
2. Age-stratified and experience-targeted training programs.
3. Mandatory IT training during onboarding and regular intervals.
4. Continuous reinforcement and ongoing organizational support.
5. Enhanced resources in resource-limited settings.
6. Organizational commitment and leadership for sustainable improvements.

Evidence Gaps and Future Research

1. Long-term effectiveness and sustainability (minimum 12-24 month follow-up).
2. Patient outcomes and clinical impact of competence improvements.
3. Standardized, validated competence assessment instruments.
4. Comparative effectiveness of different training modalities.
5. Organizational factors and implementation science approaches.
6. Qualitative research on professional experiences and barriers.

The finding that the overall digital competence of healthcare professionals reached 68.2% indicates a moderate level of readiness for healthcare digitalization, yet it simultaneously reveals a substantial competence gap, as nearly 40% of personnel still demonstrate inadequate digital skills. This result can be explained through the lens of the Digital Competence Framework (DigComp), which emphasizes that digital

competence is a multidimensional construct encompassing information literacy, communication, content creation, safety, and problem-solving abilities. The moderate competence level observed in this study suggests that while healthcare professionals have generally adapted to the increasing use of electronic health records, telemedicine, and digital health systems, many still struggle to fully integrate advanced digital technologies into clinical practice. These findings are consistent with previous studies showing that healthcare workers often possess basic operational digital skills but lack higher-order competencies required for data-driven decision-making and digital innovation (Konttila et al., 2019; Heponiemi et al., 2018). However, the competence level reported in this review is slightly higher than that found in earlier studies conducted before the COVID-19 pandemic, indicating that accelerated digital transformation in healthcare may have contributed to improved competence levels. Scientifically, this trend supports the argument that environmental demands and technology exposure act as catalysts for competence development, although improvements remain uneven across healthcare systems.

Another important finding is the significant variation in digital competence across professional groups and healthcare settings. Physicians demonstrated higher competence levels than nurses, while personnel in tertiary hospitals outperformed those in primary healthcare settings. This disparity can be interpreted through the Technology Acceptance Model (TAM), which argues that technology adoption is influenced by perceived usefulness and perceived ease of use. Physicians working in tertiary hospitals are generally exposed to more sophisticated health information systems, clinical decision-support tools, and continuous professional development opportunities, increasing both familiarity and confidence in using digital technologies. These findings align with previous research by van Houwelingen et al. (2016) and more recent studies reporting that healthcare professionals working in technologically advanced institutions tend to develop stronger digital competencies due to greater organizational support and infrastructure availability. Nevertheless, the magnitude of the gap identified in this study appears larger than that reported in some earlier investigations, suggesting that inequalities in access to digital resources remain a persistent challenge. This difference highlights the importance of considering institutional context as a critical determinant of digital competence and reinforces the need for equity-oriented digital capacity-building strategies within healthcare systems.

The study also found that age and professional experience were negatively associated with digital competence, whereas formal IT training and self-efficacy

exerted strong positive effects. This finding is theoretically supported by Social Cognitive Theory, which posits that self-efficacy significantly influences an individual's willingness to engage with and master new technologies. Older and more experienced healthcare professionals may encounter greater difficulty adapting to rapidly evolving digital environments because their professional training often occurred before the widespread integration of digital technologies into healthcare practice. Conversely, structured training programs enhance confidence, knowledge, and practical skills, thereby improving digital competence. The observed 18.5% increase in competence following training interventions confirms the effectiveness of professional development initiatives and is consistent with recent evidence demonstrating the positive impact of digital literacy programs in healthcare settings. However, the reported 28% skill decay after six months suggests that competence acquisition alone is insufficient without continuous reinforcement and organizational support. This finding extends previous literature by highlighting the sustainability challenge of digital competence interventions and implies that healthcare organizations should move beyond one-time training approaches toward continuous learning ecosystems that foster long-term digital capability development and adaptation to technological change (Heponiemi et al., 2018; World Health Organization, 2021; European Commission, 2022).

CONCLUSION

Medical personnel demonstrate varying levels of digital competence that are influenced by demographic, institutional, and educational factors, with nearly 40% exhibiting inadequate competence levels, highlighting a significant gap in healthcare workforce preparedness for digital transformation. Age and professional experience have emerged as important and potentially modifiable risk factors, suggesting the need for targeted interventions aimed at specific workforce groups. The strong association between formal training and higher competence levels, coupled with the finding that approximately 35% of healthcare professionals have not received structured digital training, underscores substantial opportunities for workforce development and capacity building. Although digital competence training programs have shown promising short-term effectiveness, evidence regarding their long-term sustainability remains limited. Therefore, achieving sustainable improvements in digital competence requires systematic baseline assessments, mandatory and continuous training programs, ongoing organizational support, leadership commitment, and the integration of digital competence development into professional education and career advancement frameworks. Given the increasing reliance on

digital technologies in healthcare, digital competence should be regarded as a core professional requirement that directly contributes to clinical effectiveness, patient safety, and healthcare quality.

Future research should prioritize long-term follow-up studies, investigate the impact of digital competence on clinical outcomes, develop standardized assessment instruments, and apply implementation science approaches to identify the most effective strategies for enhancing and sustaining digital competence among healthcare professionals.

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