Unveiling the digital future: perspectives of Hungarian physicians under 35 years old on eHealth solutions

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Background: The COVID-19 pandemic has catalysed the emergence of digital solutions in all areas of medicine. Our prior study on the digital health related experiences and opinions of Hungarian physicians highlights the crucial role of age in shaping attitudes towards digital health solutions among medical doctors. Our aim was to examine how under 35-year-old Hungarian physicians relate to digital technologies, the advantages and disadvantages they perceive, and how they would like to incorporate these technologies into their everyday medical practice.

Methods: As part of the "E-physicians and E-patients in Hungary" study, we conducted an online representative survey among medical practitioners in Hungary between July 2021 and May 2022 ($n = 1,774$). The main target group of our research were physicians under 35 years of age: $n = 399$ (25.3%). Besides descriptive statistical analyses, cluster analysis and binary logistic regression were applied to analyse the digital health related attitudes of the young age group.

Results: Our cluster analysis confirmed that younger doctors perceived more advantages (on average 7.07 items vs. 8.52 items) and disadvantages (on average 4.06 vs. 4.42) of digital health solutions. They also demonstrated greater familiarity with (8.27 vs. 9.79) and use of (1.94 vs. 2.66) a broader spectrum of technologies. Proficiency and active utilization of diverse technologies correlates with a more comprehensive understanding of both pros and cons, as well as a more realistic self-assessment of areas of further improvement. Doctors under 35 years express a notable demand for significantly increased incentives, both in terms of knowledge transfer/training and infrastructure incentives. Multivariate analyses revealed that young doctors, compared to their older counterparts, perceived enhanced patient adherence as one of the greatest benefits of digital health solutions. Additionally, young doctors expect that digital health solutions could reduce burnout.

Conclusion: Our results underscore the inevitable transformation of the 21st-century physician role: the success of digital health solutions hinges on active patient involvement and management, which requires proper patient education and professional support in navigating the digital space. Digital health solutions can be a bridge between different generations of doctors, where young people can help their older colleagues navigate the digital world.

KEYWORDS

digital health, young doctors, adherence, paradigm shift, participatory medicine, e-physcians, burnout

Abbreviations
HMC, Hungarian Medical Chamber; WHO, World Health Organization.

1 Introduction

The digital transformation of healthcare has become a central issue, profoundly influencing both the current state of health care provision and its future trajectory (1). This shift is reshaping health care organization, human resource management, and even issues of equity and access to care. While it offers solutions to longstanding challenges, it also presents new obstacles. Therefore, it is crucial to understand the factors that encourage both doctors and patients to adopt digital health solutions (2, 3).

Age plays an essential role in digital adaptability. Survey data from the European Commission highlights a substantial increase in daily internet usage among younger populations: in 2021, 95% of young people used the internet daily across Europe, compared to 82% in 2012. By 2023, this figure reached 97% of individuals aged 16–29, compared to 86% of the total population (4). There is evidently a clear correlation between youth and prolonged internet engagement. A pertinent question arises: does increased digital engagement in younger age groups mean they are more likely to embrace digital health solutions?

The concept of Digital Natives, introduced in 2001, remains under debate. In 2009 Prensky suggested that "Digital Wisdom" would be a more fitting term (5). It indicates that as consecutive generations enter the 21st century, nearly everyone will have some digital experience from an early age. This has blurred the divide between "Digital Native" and "Digital Immigrant". While younger people may be more familiar with digital devices, they still require guidance to use technologiy effectively. Older generations are also rapidly narrowing the gap by using digital innovations and becoming digitally wise. Interestingly, studies show that younger individuals do not necessarily posess better eHealth literacy than older adults (6).

It is generally assumed that young people, including young medical professionals, navigate the digital world with ease. The literature provides evidence in support of this notion. Park and Kwon's systematic review of health-related internet use of children and adolescents show that a high percentage of youth use the internet for health-related purpose (7). Their primarily aim is to find information on daily health related topics. The review also found that many young individuals engege in online health communities and activities such as messaging, networking, and information seeking.

Although the use of digital solutions in healthcare predates COVID-19, it was the imposed isolation and increased medical work load caused by the pandemic that boosted digitalization into mainstream healthcare.

The 2023 survey study of Siragusa et al. highlighted the positive effects of the SARS-CoV-2 crisis on Italian surgical practice (8). One significant development was the increase in the use of teleconsultations for pre and post operation patient management in all forms of surgery (up from 4.1% to 21.6%). Another was the use of digital solutions for diagnostic evaluations (an increase from 16.4% to 42.2%). Finally, there was a big change in surgical professional development in the form of attending e-congresses and participating in online education. Surgeons' personal education online increased from 12.6% (pre-COVID) to 86.6%).

The surgeons in the study expressed the desire to continue with teleconsultations and tele-education in the future.

Despite these advancements, relatively little is known about young doctors' (under 35) attitudes to E-health solutions. Research is scarce in the field. According to the American Medical Association's 2022 study on physicians' motivations and expectations for the adaptation of eHealth solutions, the use and acceptance of digital health tools was growing among US based doctors across all ages (9). Although age once influenced enthusiasm for teleHealth according to the results of the 2016 survey, by 2022 this disparity faded, with all age groups recognizing the advantages of digital health solutions. While the 51+ age group has the lowest number of those who see a definite advantage in using digital tools in patient care, they have experienced the largest increase. By 2022 age played no role in the use of remote monitoring in patient care. Similarly, a study from Poland (10) revealed, that 70.4% of the surveyed physicians were familiar with new technologies and rated their eHealth literacy as high, but digital skills decreased significantly with physicians' age. A comparative study in Hong Kong and Bahrain (11) showed that doctors accept smart phone use in a clinical setting but noted differences by age: 48% of the junior doctors claimed high reliance on smartphones, whereas only 32.3% of the senior doctors reported the same. Correspondingly, a Nigerian survey concluded that doctors under the age of 40 years, particularly Interns, were significantly more likely to perform smartphone-based activities during their hospital work (12). A national survey of the Italian Young Medical Doctors Association (13) found that only a small proportion of young doctors interviewed claimed to have had any significant experience with digital health solutions, like telemedicine tools (22%), big data, omics technology and predictive models, or AI (each 13%), internet of things (6%).

Studies also underscore the need for practical training to keep pace with the digital revolution as most respondents report insufficient preparedness to use digital technologies due to limited exposure to such technologies in medical school (10, 13, 14). While medical students generally hold positive attitudes towards the use of digital health tools in education and patient care, many lack formal training in this field (15, 16).

In our prior study on the eHealth related experiences and opinions of Hungarian physicians (2), we found age to be a significant factor in attitudes towards digital health solutions among medical doctors. The youngest age group displayed the most enthusiasm, while the age group between 35 and 45 was the most intensive user. Our Hungarian population survey on digital health use and attitudes (17) also suggest that age 60 is a critical threshold for both current and planned digital technology use. Additionally, doctors working in the private sector are more prone to recommending websites, applications, or social media sourcse and use telemedicine more often, however, no significant sector-based differences emerged in the use of advanced digital tools like sensors, portable diagnostic devices, AR, VR, robotics, AI and 3Dprinting.

The present study aims to explore the digital health solutions related attitudes of doctors under 35 years, compared to those of

older physicians. We investigate the digital tools they prefer to use and the perceived benefits and disadvantages of digital solutions. This topic is critical for both the future of healthcare providers and the patients they serve.

As digital health is a quite broad concept, we have tried to cover as wide a spectrum as possible in our study. The surveyed areas included different activities, like participating in online conferences and trainings, tracking international literature, trends, and data online, telemedicine, smartphone applications, healthcare-related social media, communication with patients, information sharing, home-usable healthcare sensors, smart devices, portable diagnostic devices (e.g., mobile ultrasound, mobile ECG), augmented reality (e.g., surgical practice), use of Virtual Reality (e.g., pain management, psychotherapy), 3D printing (e.g., dental, surgical solutions), Artificial Intelligence solutions in medical decision-making (radiology, pathology, ophthalmology, diagnostic solutions), robotics (e.g., surgical robots, disinfection robots, delivery robots) or anotechnology (e.g., ingestible diagnostic devices).

2 Methodology

2.1 Recruitment and sample

W e conducted an online survey among medical doctors working in Hungary s part of the "E-physicians and E-patients in Hungary" study (2). The questionnaire was made available online in a self-administered format from July 2021 to May 2022. Our self developed questionnaire is a medical version of the questionnaire used in the population survey (17). The research call with the questionnaire link was emailed to all practising doctors in Hungary (approximately 35.000 people), based on the medical chamber register. All doctors in Hungary had the same chance of being included in the sample, because the Hungarian Medical Chamber (HMC) membership was mandatory for each practising medical doctor.

After the questionnaire was sent out, several reminder emails were sent to increase response rate.

1. **Initial Distribution and Reminders (Summer 2021):** The first wave of invitations and reminders was distributed during the summer of 2021. This period saw lower engagement due to the ongoing pandemic pressures.
2. **Newsletter Campaign (Autumn 2021):** A follow-up campaign was launched in autumn 2021, involving a newsletter sent to HMC members. This aimed to remind and encourage participation among those who might have missed or overlooked the initial emails.
3. **Targeted Email Survey (Spring 2022):** After the COVID-19 epidemic had subsided, a more targeted email survey was conducted in spring 2022. This was done in agreement with the HMC to reach out specifically to physicians who had not yet participated.

A total of 1,774 questionnaires were received, consisting of 1,576 general medical doctors and 198 dentists. Dentist participants were excluded from the present analysis for methodological issues. The target group of our present study are physicians under 35 years of age: $n = 399$ (25.3%).

2.2 Measuring instruments

Correction weighting was applied to the responses based on the statistics obtained from the National Register of Practising Medical Doctors. The Directorate of Human Resources Development of the Ministry of Health provided the register. The correction weighting considered factors such as gender, age, and the county where the workplace is, based on the data of the Hungarian Central Statistical Office (18). This correction was necessary due to slight variations in the sample compared to the main distributions of the Register (19). The weight variable had a mean value of 1, a first quartile value of 0.6255, and a third quartile value of 1.1942.

The questionnaire contained items on knowledge, interest, expectation, and use of digital health technologies. The majority of items were on a 5-point Likert scale.

were Sociodemographic data, frequency of internet use for work, knowledge and use of digital health technologies, needs for digital technologies, and positive and negative attitudes towards the use of digital health solutions were the main blocks of the 25-question, 15-min questionnaire.

The questionnaire can be found in the Supplementary Material.

In this research, we looked at digital solutions that our respondents know and use, or are planning to use (in both cases, the top 2 categories of 5-category Lickert scaling questions were considered to be frequently used or intensively used). The internal consistency of the questions was tested using a cronbach's alpha test. The questions on digital technologies (4.1–4.39) were divided into 3 subscales based on "Knowledge", "Use" and "Willingness to use".

The Cronbach alpha results for the subscales are. Knowledge (13 items) 0.830, Use (13 items) 0.743 Willingness to apply (13 items): 0.882. These indicators confirmed the reliability of the scales.

We also asked about the perceived advantages and disadvantages of digital health solutions and assessed what help doctors feel they would need to use digital solutions more effectively. The last question was divided into two parts: training aspects (undergraduate, postgraduate training, available protocols, recommendations) and infrastructure aspects (accessibility, affordability, ease of use).

2.3 Statistical analysis

Data analysis was performed using IBM Statistics (SPSS 28) (20). The statistical data processing involved examining distributions, conducting cross-tabulation analyses, and performing chi-square tests. Cross-tabulation analyses were conducted using the chi-square test, means were compared using analysis of variance (ANOVA). Logistic regression and K-means analysis were also utilized for deeper context. In our statistical analysis, a significance

level of 5% ($p < 0.05$) was applied. Significant associations ($p < 0.05$) are marked in bold in the tables.

The variables used in the analysis were derived from the raw data by aggregating the responses to each question on an individual basis (e.g., assessing the perceived benefits of digital health solutions).

We subsequently ran a K-means cluster analysis, using the variables described above, to test whether two or more groups of digital device users are indeed separated from each other in terms of digital device use.

Finally, we built a multivariate model using logistic regression. The dependent variable was one of the response options of the multiple-choice question asking about the benefits of digital health solutions: it increases patient cooperation and adherence (values: 0 = not selected, 1 = selected). The model was run using a forward conditional variable selection method including a number of variables (age, gender, being a GP or not, the number of advantages and disadvanteges of digital healthcare solutions seen, the number of solutions patients express a need for, the number of digital health solutions the doctor is familiar with, the number of technologies used frequently or on a daily basis, the amount of support that would be necessary (training, protocols, knowledge sharing) to adopt digital healthcare solutions and the amount of support apart from training or knowledge sharing that would be needed to use digital healthcare solutions.

2.4 Ethical consideration

This study adhered to ethical guidelines and received approval from TUKEB (Hungarian Scientific Research and Research Ethics Committee) with the reference number IV-10927-1 TUKEB. The research based on anonymized survey data and did not involve interventions or identifiable personal information. Participants provided informed consent by voluntarily completing and submitting the survey online. Confidentiality and anonymity of participants were strictly maintained throughout data collection, analysis, and reporting.

3 Results

3.1 Demographic profile of the sample

The sample included 399 (25.3%) doctors who were 35 years and under, 845 (53.6%) in the 36–64 age group and 331 (21%) in the 65+ age group. The youngest age group shows a strong female predominance with 62.3% women and 37.8% men. For those aged 65 and over, the gender split is almost even: 47.1% men and 52.9% women. A significant proportion of under-35 s work in inpatient care: 51.6% in hospitals and 29.2% in university clinics. Consequently, the location of their workplace is significantly Budapest (37.5%) and the county seats (41.3%). (See Table 1 for the details).

3.2 Outcomes

3.2.1 Familiarity with digital technologies

Looking at individual technologies, following the online literature, apps, various sensors, smart devices, wearable diagnostic devices, AR/VR applications, 3D printing, AI based solutions for robotics and nanotechnology, a significantly higher proportion of the under 35 s indicate that they are more familiar with these technologies (Table 2).

3.2.2 Use of digital technologies

In addressing the usage of various digital technologies, we utilized responses falling within the range of 4–5 on a Likert scale, where participants indicated frequencies of "often/very often" or daily as the frequency of using different technologies.

Those under 35 showed a significant average in the use of online literature search, apps sensors, smart devices, use of smart devices. On the other hand, the age group 36–64 showed a surplus in the use of teleHealth and social media. (Table 3).

3.2.3 Intention of usage of various digital technologies in the next 3 years

For this question, we also used the 4–5 often/very often responses—so we focused on regular users rather than those who just tried them once.

In terms of planned use, young respondents are significantly more likely to want to use online conferencing, apps/sensors, smart devices, mobile diagnostics, AR/VR, 3D technology, robotics, AI and nanotechnology (Table 4).

3.2.4 Perceived need to facilitate the use of digital solutions

A significantly higher proportion of doctors under 35 indicated that financial incentives, accessible professional materials, availability of technologies, evidence-based studies, clarification of legal-ethical issues, data security, existence of different professional protocols and patient engagement would be a prerequisite for the higher uptake of digital solutions.

It can also be seen that on average, doctors under 35 years cited the need for more incentives, both in terms of knowledge transfer/training and infrastructure incentives (Table 5).

3.2.5 Perceived benefits of different digital solutions by young doctors—a paradigm shift

Overall, younger doctors tend to mention more benefits. A significantly higher proportion reported improved efficiency, improved diagnostic skills, reduced burnout, increased patient adherence, better patient involvement in the healing process, increased patient cooperation, more comfort, time saving, improved quality of care and reduced rate of malpractice. Also a higher proportion of young doctors think that using digital tools will bring extra income to their practice (Table 6).

3.2.5.1 Perceived disadvantages of using digital tools

Doctors under 35 years also mention more disadvantages on average than the other two age groups. They cite significantly higher rates of

TABLE 1 Demographic profile.

			35 years old and younger	36–64 years old	65 years old or older
Gender ($p < 0.05$)	Male	n	151	351	156
		%	37.8%	41.5%	47.1%
	Female	n	249	494	175
		%	62.3%	58.5%	52.9%
	Total		400	845	331
Type of workplace ($p < 0.05$)	University, college	n	23	43	13
		%	5.8%	5.1%	3.9%
	Research institute	n	3	0	1
		%	0.8%	0.0%	0.3%
	Clinic, national specialized hospital	n	116	89	17
		%	29.2%	10.5%	5.1%
	Hospital	n	205	228	54
		%	51.6%	27.0%	16.3%
	Clinic, other specialist medical institution	n	5	102	74
		%	1.3%	12.1%	22.4%
	General practice	n	26	278	110
		%	6.5%	32.9%	33.2%
	Private healthcare service provider	n	14	64	43
		%	3.5%	7.6%	13.0%
	Multinational company	n	0	6	1
		%	0.0%	0.7%	0.3%
	Hungarian company	n	3	15	5
		%	0.8%	1.8%	1.5%
	Public administration	n	0	6	0
		%	0.0%	0.7%	0.0%
	Health and health-related professional organizations	n	0	1	1
		%	0.0%	0.1%	0.3%
	Other	n	2	13	12
		%	0.5%	1.5%	3.6%
	Total		397	845	331
Settlement type of workplace ($p < 0.05$)	Capital	n	149	256	100
		%	37.5%	30.4%	30.3%
	County seat	n	164	283	86
		%	41.3%	33.6%	26.1%
	Town	n	67	250	119
		%	16.9%	29.7%	36.1%
	Village, countryside	n	17	54	25
		%	4.3%	6.4%	7.6%
	Total		397	843	330

Significant correlations are marked in bold.

overdiagnosis, patients misinterpreting the data they share, technological errors that jeopardise patient recovery, data protection problems, and increased administrative burden (Table 7).

3.2.6 Cluster analysis

In the next step, we ran a K-means cluster analysis on the data to investigate whether the younger age group is indeed distinct from older doctors in their attitudes towards digital health technologies. The final model with two clusters was generated as a result of the run, where the distribution of item numbers is half and half, with 786 people in the first cluster and 788 in the second cluster. The final cluster centres table shows that the two groups differ significantly and spectacularly in age (63.29 vs. 36.35), and there are also differences in the other variables included in the model. Younger doctors perceive more advantages (7.07 vs. 8.52) and

disadvantages (4.06 vs. 4.42) of digital health solutions, are more familiar with (8.27 vs. 9.79) and use (1.94 vs. 2.66) more technologies. There is no significant difference in the needs perceived by patients (3.84 vs. 3.90) and in the amount of things they would need training or knowledge transfer for (2.43 vs. 2.63). Other differences (no training or knowledge transfer) are also visible between the two groups (3.18 vs. 4.02) (Table 8).

3.2.7 Logistic regression model for patient adherence and use of digital solutions

As a last step of our analysis, we ran a multivariate model with logistic regression, where the dependent variable was the question of increasing patient adherence (0 = not marked, 1 = marked). The final logistic regression model included 5 explanatory variables (Nagelkerke R-square = 0.261).

TABLE 2 Familiarity with digital technologies among Hungarian medical doctors, by age group.

		35 years old and younger	36–64 years old	65 years old or older
Participating in online conferences and trainings	n	386	835	310
	%	97.0%	99.2%	94.5%
Tracking international literature, trends, and data online	n	389	766	260
	%	97.5%	91.1%	79.3%
Telemedicine, remote visit	n	338	755	261
	%	85.4%	89.7%	79.1%
Smartphone applications, apps	n	382	742	236
	%	95.5%	88.4%	72.4%
Healthcare-related social media, communication with patients, information sharing	n	321	655	215
	%	80.5%	77.8%	65.5%
Home-usable healthcare sensors, smart devices	n	386	730	250
	%	96.7%	86.7%	76.5%
Portable diagnostic devices (e.g., ultrasound, mobile ECG)	n	382	720	255
	%	96.0%	85.8%	78.2%
Augmented reality (e.g., surgical practice)	n	204	302	79
	%	51.0%	35.9%	24.2%
Use of Virtual Reality (e.g., pain management, psychotherapy)	n	168	276	98
	%	42.0%	32.9%	29.8%
3D printing (e.g., dental, surgical solutions)	n	285	465	116
	%	72.0%	55.4%	35.5%
Artificial intelligence solutions in medical decision-making (radiology, pathology, ophthalmology, diagnostic solutions)	n	254	439	131
	%	63.5%	52.1%	40.1%
Robotics (e.g., surgical robots, disinfection robots, delivery robots)	n	255	416	123
	%	64.1%	49.3%	37.5%
Nanotechnology (e.g., ingestible diagnostic devices)	n	302	546	194
	%	76.1%	65.1%	59.3%

Significant correlations are marked in bold.

TABLE 3 Usage of digital technologies among Hungarian medical doctors, by age group.

		35 years old and under	36–64 years old	65 years old or older
Participating in online conferences and trainings	n	138	348	81
	%	34.5%	41.3%	24.5%
Tracking international literature, trends, and data online	n	238	377	105
	%	60.1%	44.8%	31.9%
Telemedicine, remote visit	n	101	382	93
	%	25.4%	45.4%	28.4%
Smartphone applications, apps	n	256	368	70
	%	64.2%	43.7%	21.4%
Healthcare-related social media, communication with patients, information sharing	n	58	175	48
	%	14.5%	20.8%	14.6%
Home-usable healthcare sensors, smart devices	n	123	183	53
	%	30.8%	21.7%	16.1%
Portable diagnostic devices (e.g., ultrasound, mobile ECG)	n	70	139	48
	%	17.5%	16.5%	14.6%
Augmented reality (e.g., surgical practice)	n	6	10	5
	%	1.5%	1.2%	1.5%
Use of Virtual Reality (e.g., pain management, psychotherapy)	n	9	25	9
	%	2.3%	3.0%	2.7%
3D printing (e.g., dental, surgical solutions)	n	2	6	0
	%	0.5%	0.7%	0.0%
Artificial intelligence solutions in medical decision-making (radiology, pathology, ophthalmology, diagnostic solutions)	n	28	37	9
	%	7.0%	4.4%	2.8%
Robotics (e.g., surgical robots, disinfection robots, delivery robots)	n	4	10	0
	%	1.0%	1.2%	0.0%
Nanotechnology (e.g., ingestible diagnostic devices)	n	2	8	3
	%	0.5%	0.9%	0.9%

Significant correlations are marked in bold.

TABLE 4 Intention of usage of digital technologies in the next 3 years among Hungarian medical doctors, by age group.

		35 years old and younger	36–64 years old	65 years old or older
Participating in online conferences and trainings	n	294	516	139
	%	73.7%	61.4%	42.5%
Tracking international literature, trends, and data online	n	353	542	136
	%	89.6%	64.8%	41.2%
Telemedicine, remote visit	n	197	445	106
	%	49.3%	53.0%	32.3%
Smartphone applications, apps	n	317	475	93
	%	79.6%	56.7%	28.6%
Healthcare-related social media, communication with patients, information sharing	n	128	257	65
	%	32.7%	30.7%	20.0%
Home-usable healthcare sensors, smart devices	n	267	374	84
	%	67.1%	44.4%	25.7%
Portable diagnostic devices (e.g., ultrasound, mobile ECG)	n	309	373	90
	%	77.8%	44.7%	27.6%
Augmented reality (e.g., surgical practice)	n	138	114	10
	%	34.6%	13.5%	3.1%
Use of Virtual Reality (e.g., pain management, psychotherapy)	n	109	105	21
	%	27.3%	12.5%	6.4%
3D printing (e.g., dental, surgical solutions)	n	155	131	12
	%	38.8%	15.6%	3.7%
Artificial intelligence solutions in medical decision-making (radiology, pathology, ophthalmology, diagnostic solutions)	n	172	240	34
	%	43.1%	28.6%	10.4%
Robotics (e.g., surgical robots, disinfection robots, delivery robots)	n	137	139	17
	%	34.4%	16.6%	5.2%
Nanotechnology (e.g., ingestible diagnostic devices)	n	172	197	39
	%	43.1%	23.4%	11.9%

Significant correlations are marked in bold.

TABLE 5 Perceived need for using digital technologies among Hungarian medical doctors, by age group.

		35 years and under	36–64 years old	65 years old or older
Financial incentives (e.g., support for acquiring certain tools)	n	303	571	202
	%	75.9%	67.6%	61.0%
Postgraduate training	n	94	300	158
	%	23.5%	35.5%	47.7%
Other training opportunities	n	179	367	142
	%	44.9%	43.4%	42.9%
Accessible professional materials (documents, online training, etc.)	n	287	493	172
	%	71.9%	58.3%	52.0%
Availability and accessibility of technologies	n	328	574	165
	%	82.0%	67.9%	49.8%
Recommendations from colleagues	n	69	129	40
	%	17.3%	15.3%	12.1%
Evidence-based research	n	221	320	91
	%	55.3%	37.9%	27.5%
Ethical and legal regulations	n	255	484	150
	%	63.9%	57.3%	45.3%
Professional protocols	n	298	508	189
	%	74.7%	60.2%	57.1%
Data security protocols	n	247	420	130
	%	61.8%	49.7%	39.3%
Dedicated time within working hours	n	294	600	166
	%	73.7%	71.0%	50.2%
Patient commitment and increased collaboration	n	209	355	145
	%	52.4%	42.0%	43.8%

Significant correlations are marked in bold.

TABLE 6 Perceived benefits of digital technologies among Hungarian medical doctors, by age group.

		35 years old and under	36–64 years old	65 years old or older
Improved efficiency	*n*	313	578	200
	%	78.4%	68.4%	60.4%
Enhanced safety	*n*	122	227	96
	%	30.6%	26.9%	29.0%
Improved diagnostic capabilities	*n*	199	349	145
	%	49.9%	41.3%	43.8%
Reduced burnout	*n*	147	233	63
	%	36.8%	27.6%	19.0%
Increased patient adherence and collaboration	*n*	265	457	139
	%	66.3%	54.1%	42.0%
Convenient	*n*	331	563	187
	%	83.0%	66.6%	56.5%
Reduced the number of in-person doctor-patient meetings	*n*	209	547	178
	%	52.4%	64.7%	53.8%
Save time for the doctor	*n*	271	473	152
	%	67.8%	56.0%	45.9%
Save time for the patient	*n*	282	562	170
	%	70.7%	66.5%	51.4%
Enable faster access to healthcare	*n*	207	453	147
	%	51.9%	53.6%	44.4%
Make your work more efficient	*n*	236	418	126
	%	59.1%	49.5%	38.1%
Engage patients more actively in their own healing process	*n*	216	403	117
	%	54.1%	47.7%	35.3%
Improve the quality of care	*n*	187	309	104
	%	46.9%	36.6%	31.4%
Reduce the likelihood of errors	*n*	103	147	57
	%	25.8%	17.4%	17.2%
Generate additional income for doctors	*n*	54	65	10
	%	13.5%	7.7%	3.0%
Increase patient satisfaction	*n*	251	400	115
	%	62.9%	47.3%	34.7%
Improve doctor-patient communication	*n*	193	353	158
	%	48.4%	41.8%	47.7%

Significant correlations are marked in bold.

TABLE 7 Perceived disadvantages of digital technologies among Hungarian medical doctors, by age group.

		35 years old and under	36–64 years old	65 years old or older
Decreased quality of care	*n*	115	268	96
	%	28.8%	31.7%	29.0%
Frustration among patients	*n*	67	183	75
	%	16.8%	21.7%	22.7%
Potential for overdiagnosis	*n*	223	259	100
	%	55.9%	30.7%	30.2%
Misinterpretation of shared health data by patients	*n*	287	522	221
	%	71.9%	61.8%	66.8%
Increased possibility of misunderstandings in doctor-patient communication	*n*	188	433	163
	%	47.1%	51.2%	49.2%
Faulty technology jeopardizing patient recovery	*n*	126	196	79
	%	31.6%	23.2%	23.9%
Compromised confidentiality of patient data	*n*	191	367	116
	%	47.9%	43.4%	35.0%
Increased administrative burdens on doctors	*n*	229	435	159
	%	57.4%	51.5%	48.0%
Additional costs for practices	*n*	143	302	109
	%	35.8%	35.7%	32.9%
Limited patient proficiency in using digital technologies, placing a burden on the treating physician	*n*	229	433	189
	%	57.4%	51.2%	56.9%
Increased likelihood of burnout	*n*	42	100	31
	%	10.5%	11.8%	9.4%

Significant correlations are marked in bold.

TABLE 8 Clusters of Hungarian medical doctors, by digital technology use.

	Final cluster centers	
	1	2
How many advantages do digital healthcare solutions have?	7.07	8.52
How many disadvantages do digital healthcare solutions have?	4.06	4.42
How many solutions do your patients express a need for?	3.84	3.90
How many digital health solutions are known by you?	8.27	9.79
How many technologies do you use frequently or on a daily basis?	1.94	2.66
Age of respondent	63.29	36.35
How much support would be necessary (training, protocols, knowledge sharing) for you to adopt digital healthcare solutions?	2.43	2.63
Apart from training or knowledge sharing, how much support would be needed for you to use digital healthcare solutions?	3.18	4.02
n	786	788

TABLE 9 Logistic regressions to determine the factors associated with increasing patient adherence.

Nagelkerke R-square = 0,261						
	B	S.E.	Wald	df	Sig.	Exp(B)
Age of respondent	−0.009	0.004	6.070	1	0.014	0.991
Gender of respondent (reference: 1 = male; 2 = female)	0.336	0.116	8.459	1	0.004	1.399
How many technologies do you use frequently or on a daily basis?	0.072	0.033	4.695	1	0.030	1.075
How much support would be necessary (training, protocols, knowledge sharing) for you to adopt digital healthcare solutions?	0.167	0.037	20.117	1	0.000	1.182
Apart from training or knowledge sharing, how much support would be needed for you to use digital healthcare solutions?	0.220	0.019	138.769	1	0.000	1.246
Constant	−1.843	0.296	38.883	1	0.000	0.158

The age of the responding physician is a significant explanatory factor in the model, with an odds ratio of 0.991 CI: 0,983–0,998) so the older someone is, the less likely they are to think that digital health solutions increase patient adherence. The gender variable is also significant, with a positive odds ratio, so women are more likely to think that it increases adherence.

Other significant explanatory variables are the number of technologies used often or every day, the number of needed technologies (not knowledge, training or knowledge transfer, but infrastructure), and perceived benefits (other than increasing patient adherence). These variables are all odds ratios above 1, so the correlation is positive, i.e., the more technology used, the more infrastructure items would be needed, and the more benefits perceived from digital health solutions, the more likely they are to think it increases patient adherence (Table 9).

4 Discussion

The WHO report "Global strategy on digital health 2020–2025", showed that digital technologies were essential for sustainable health systems and universal health coverage (21). Digital health, or eHealth, uses information and communication technologies and networks to manage, deliver and optimise patient care and health services. According to WHO data there are currently 5–7 million health workers missing from health systems worldwide (22). One possible alternative of addressing the health workforce shortage is the increasing use of digital technologies in various care settings.

A systematic review of 123 studies, encompassing data from approximately 250,000 healthcare providers globally, revealed that the adoption of mobile technologies, telemedicine, and various digital tools for clinical decision support has positively impacted the performance, mental well-being, skills, and competencies of health workers (23).

In this context, a key question is how young doctors relate to digital technologies, what advantages and disadvantages they see in these possibilities and how they would like to incorporate their use into their everyday medical practice.

Digital transformation in the health sector is not a simple matter of technical change, but requires adaptive changes in human attitudes and skills, too (24). The past 20 years have seen the emergence of e-patients and e-physicians. E-patients are active partners in the care they receive while manifesting the power of the participatory medicine model. The "e" stands for "electronic", "equipped", "enabled" "empowered", "engaged" and "expert" (25). On the other side, e-physicians are "electronic" as they use digital technologies in their practice with ease. They are "equipped" because they have digital health technologies at their disposal. They are "enabled" by regulations and guidelines and "empowered" by technologies that support their job. They are "engaged" in as much as they have empathy to understand the feelings and point of view of patients, give them relevant feedback and involve them throughout the whole healing process. Finally, they are "experts" in using technologies in their practice and knowing the best and most reliable and trustworthy sources and technologies. As we can see from these definitions, being an e-patient or e-physician goes beyond digital proficiency, it is also an attitude and an orientation (24, 26).

Digital health solutions make new approaches of care possible by moving diagnosis, treatment, and prevention out of the clinic s into the everyday settings of people's lives (27). From this perspective, the dynamics of the doctor- patient relationship in the 21st century are influenced by the possibilities inherent in digital solutions and the democratization of health care. This phenomenon is best captured by the phrase of *Participatory Medicine*. Participatory Medicine is a movement in which patients and health professionals actively collaborate and encourage one another as full partners in healthcare. Hood and Auffray defined it in 2013 as "an approach of cooperative health care that actively and continuously involves patients and other stakeholders (i.e., healthcare providers and caregivers), across the continuum of care" (28).

Participatory medicine is an attitude. It is a considerable shift from the parentalistic paternalistic medical model characteristic of the 20th century and before. Patients are accepted as partners and joint decision making is favoured. It started before digitalisation in healthcare with the patients' rights movement and the legal requirement of informed consent. Digitalisation suits this model as in essence it facilitates the information flow towards patients. They are given access to Electronic Health Records, they have tools to monitor their health status at home with wearable devices. They have easier access to their healthcare provider through telemedicine. They can gain health related information from online sources and provide and receive peer support in online patient communities (29).

Our cluster analysis confirmed the hypothesis that younger individuals exhibit a greater familiarity with digital solutions. Specifically, doctors under the age of 35 demonstrated a significantly higher level of familiarity with utilization of and future interest in digital technology. Proficiency in multiple technologies correlated with a more informed understanding of both advantages and disadvantages, fostering a realistic assessment of the need for further improvement. Our results underscore a pronounced demand for both training and infrastructure in the use of digital health-related technologies. It is noteworthy that in comparison to their elder counterparts, young doctors identify enhanced patient adherence, increased patient involvement in the healing process and heightened patient cooperation as the greatest benefits of digital health solutions. In our multivariate analysis, a clear connection emerged between young doctors, active patient involvement in the treatment process— and the pivotal role played by digital technologies in facilitating this engagement Additionally, our results highlight the indispensable nature of a proper patient-provider relationship for the successful participation and adherence process which based on mutual communication, data sharing and shared decison making (30–32).

Digital health solutions can potentially enhance patient adherence (33–35), although relevant studies are small-scale and limited. More work is needed to identify the most effective digital health interventions to further quality health care provision (34, 36–40).

Our multivariate analysis also revealed that women are more likely than their male counterparts to believe that digital health solutions have a significant role to play in improving patient adherence. Significant attention has been devoted to researching how gender of both patients and physicians are related to the overall patient experience and specific elements of the patient-physician relationship (41).

The role of digital health solutions in patient empowerment is supported by a large body of research (42–44) but little research has focused at the impact of the gender of the patient empowerment.

Another significant result of our study is that young doctors think that digital technologies may potentially be able to reduce burnout. According to the study of Rotenstein et al. nearly half of all healthcare workers suffered from burnout during the COVID-19 pandemic (45). The 2023 Physician Burnout & Depression Report of Medscape entitled "I Cry but No One Cares," is a survey of more than 9,100 doctors representing 29 specialties. This study concludes that 53% of physicians experienced burnout the previous year, which is a six percent increase from 2021. Nearly a quarter of the surveyed physicians reported having been depressed, up from 15% in 2018 (46). Our pre-pandemic Hungarian data shows that medium or high level personal accomplishment was present in 75.9% of surveyed doctors and emotional exhaustion in 58% The moderate level depersonalization subscale was 53%. All 3 aspects showed association with being under 35 years old, working in in-patient care, working shifts and multiple workplaces (47).

Evidence is still scarce, but it tends to point to the burnout-reducing potential that digital health may have. Nevertheless, we must say that initially EHR was demonstrated to negatively influence clinician well-being, contributing to clinician burnout (48). Digital health solutions can improve job satisfaction and reduce burnout supporting clinical decision-making and reducing administrative tasks (49). Digital solutions can save time, minimize repetition, improve team-work and reduce unnecessary visits (50). One of the main sources of burnout in healthcare is the overwhelming amount of administrative and repetitive tasks. For example, AI can take over administrative tasks, using natural language processing, computer vision, speech recognition, and machine learning to streamline workflow. The uncertainty and complexity of clinical decisions may also contribute to burnout. AI can ease this as a decision aid using data analytics and predictive modeling. Chatbots, virtual assistants, and teleHealth platforms enable better interaction with healthcare workers and patients. These AI-driven technologies may improve efficiency and support healthcare professionals, contributing to their well-being and combating burnout (51–53).

5 Conclusions

Our results show the inevitable transformation of the 21st century physician's role: the success of digital health solutions requires the active involvement and management of patients, which demands proper patient education and professional support in navigating the digital space (54). As for physicians, it is important to provide guidance for patients in the DH world, especially in the areas of creditibility and proper use. This raises the need to incorporate digital health skills as an important part of medical and professional training. The 2024 position paper of the European Federation of Internal Medicine (EFIM) supports this notion (55). Having used SWOT analysis and the DELPHI method to reach their conclusion, the panel of experts consulted

strongly advocates the development and application of telemedicine and digital technologies in healthcare. For this aim they emphesise the importance of professional development of eHealth competencies in the healthcare and medical workforce. They also stress the need for the development of consensus on care models or standardized protocols among European Internal Medicine specialists regarding telemedicine use.

Another important trend emerged from our findings: young doctors' needs and skills in digital technologies can be an important reference point for older colleagues. Digital health solutions can be a bridge between different generations of doctors, where young people can help their older colleagues navigate the digital world.

5.1 Research implications

The implications of digital health extend across theoretical, practical, and social dimensions, calling for an integrated approach that combines technology, education, and systemic innovation to achieve sustainable progress in healthcare.

The results of our study can be summarised in this theoretical framework as follows:

5.2 Theoretical implications

Digital health introduces a paradigm shift in healthcare emphasizing mutual care and challenging traditional hierarchies. The emergence of "e-patients" and "e-physicians" highlights the need for engagement and expertise, reflecting a systemic integration of technology and human attitudes. Digital tools address global challenges like workforce shortages and burnout by optimizing workflows and decision-making.

5.3 Practical implications

Digital health solutions enhance clinical efficiency and reduce administrative burdens through tools like telemedicine, AI-driven solutions, and mobile apps. Young doctors play a pivotal role in emphasizing the advantages of enhanced patient adherence and collaboration. Successful integration of digital health solutions depends on comprehensive training, adequate infrastructure, and effective patient education to maintain credibility and achieve full potential.

5.4 Social implications

Digital health reshapes doctor-patient relationships by promoting transparency and collaboration, as seen in Participatory Medicine. Young doctors help bridge generational divides, aiding older colleagues in adapting to new technologies.

5.5 Strengths and limitations

The strength of our research is that it analyses the proficiency and attitudes towards digital technologies of Hungarian doctors under 35 years of age in a representative sample. There is very limited published data on the digital health related attitudes of the young generation of physicians in the international literature. An additional strength is that our results are comparable with an equally representative sample of senior doctors. However, a limitation of our research is that we did not define the concept of patient adherence in our survey. It is also a limitation that burnout was measured subjectively, and no instrument was used for this. Another limitation is that a significant proportion of young doctors' work in inpatient care and urban areas which makes it difficult to compare different fields of care. One final limitation is that we have examined several different digital tools. This makes it difficult to compare knowledge, usage patterns and opportunities.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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