COVID-19's Effect on Medical Students' Digital Health Perceptions and Intentions

Mickaël Ringeval, Louis Raymond, Marie-Pascale Pomey, Guy Paré

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Abstract

Background: The COVID-19 pandemic has underscored the importance of digital health (dHealth) technologies in medical practice. Despite this, medical curricula often provide limited exposure to these technologies.

Objective: This study investigates the effects of the COVID-19 pandemic on medical students’ intentions to integrate dHealth technologies into their future practice.

Methods: We employed a two-phase survey at the University of Montreal’s medical school to assess changes in perceptions before (N=184) and after (N=138) the pandemic. The survey used component-based structural equation modeling (SEM) and qualitative comparative analysis (QCA) to analyze our dataset.

Results: Findings indicate limited exposure to dHealth technologies within the medical curriculum. However, there was a strong consensus on the necessity of formal dHealth training. A notable shift towards the acceptance of artificial intelligence (AI) and telehealth tools was observed, emphasizing the pandemic’s significant role in altering students' views on these technologies.

Conclusions: The study advocates for the integration of formal dHealth training in medical curricula to better prepare future physicians for the demands of an increasingly digital healthcare landscape. The COVID-19 pandemic has significantly influenced medical students' perceptions, highlighting the urgent need to adapt medical education to include comprehensive dHealth training.

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Keywords: Digital health, eHealth, medical education, medical practice, artificial intelligence, COVID-19, survey.

Introduction

Background

Digital health (dHealth) is broadly defined as the use of digital technologies and information systems to enhance the delivery of healthcare and improve health outcomes [1]. Precisely, it encompasses a wide range of technologies and applications that aim to enhance healthcare services, monitor health conditions, promote wellness, and facilitate communication between patients and healthcare providers. Over the past decade, dHealth has attracted a great deal of attention and been on the forefront of major digital transformation initiatives [2, 3]. Indeed, the advent of dHealth technologies has transformed the healthcare landscape, converting it into a dynamic industry, with projections soaring to over US $270 billion by 2028 [4].

The role of dHealth technologies has become more relevant than ever because of their potential to manage or prevent diseases, to reduce healthcare costs, to empower patients to self-manage chronic conditions, and to optimize the utilization of community resources, especially among the elderly and isolated [5, 6]. These technologies have also been instrumental in improving care quality, continuity, and accessibility, tailoring treatments to individual patients, and enabling remote assessment and follow-up during pandemics, as was seen during the COVID-19 crisis [7, 8]. In light of the above, physicians today are increasingly expected to possess a range of skills which include proficiency in navigating EHR interfaces, documenting patient encounters electronically, ensuring the security and privacy of patient information, effective communication skills in a remote setting, the ability to assess patients virtually, and familiarity with telehealth regulations, to name but a few.

The scientific literature underscores the importance of integrating dHealth education into medical training and highlights the pivotal role of medical students' interactions with these technologies in developing patient care competencies, dHealth knowledge, self-efficacy, and diagnostic accuracy [9-11]. Regrettably, many medical schools have been slow to incorporate dHealth into their formal curricula, leaving medical students inadequately prepared for the changing clinical landscape. Because of this underexposure, medical students often lack a comprehensive understanding of dHealth, and this can lead to misconduct such as patient confidentiality breaches that can have severe legal ramifications.

While numerous studies have identified barriers and facilitators of dHealth education in medical curricula [12, 13], much less is known about the perspectives of medical students on this matter. Moreover, previous studies have often focused on specific types of dHealth technologies, offering only fragmented insights. As we delve into this uncharted territory, it is essential to note that most studies were conducted before the onset of the COVID-19 pandemic, a global health crisis that significantly accelerated the adoption of dHealth tools.

Considering these aspects, the current two-phase survey study aims to investigate the determinants shaping medical students' intentions to use dHealth technologies in their future medical practice. Importantly, it seeks to assess the impact of the COVID-19 pandemic on medical students' perceptions and intentions related to dHealth. Accordingly, the present study addresses the following questions: 1) Post-COVID-19, are medical students inclined to integrate dHealth technologies into their future practice? 2) What factors influence their intentions? 3) Has the COVID-19 pandemic shifted or influenced medical students' attitudes and intentions towards dHealth?

By conducting a thorough analysis of medical students' perceptions before and after the COVID-19 pandemic, our research enhances the existing literature on technology adoption within medical education. This study not only addresses critical gaps in knowledge but also poses significant questions relevant to the post-pandemic context. It delivers key insights to researchers and practitioners and provides a detailed examination of the role of dHealth in medical training. Additionally, our findings offer essential guidance to educators and medical schools. This guidance is crucial as they maneuver through a rapidly changing landscape where advanced dHealth technologies are reshaping medical practice and defining the future of healthcare delivery.

The remaining of this article is organized as follows. The next section presents the theoretical background of our study which is followed by the presentation of the methodology that was used to address the research questions. We then give an account of an empirical study that was conducted and, finally, we discuss the results and their implications for research and practice.

Theoretical background and Hypotheses

To address the abovementioned research questions, we begin by developing a model with two main theoretical foundations. The first component is the Technology Acceptance Model (TAM) and all its variants. TAM provides a conceptual framework to explain how users come to adopt a new technology [16]. Building on prior research on dHealth training [e.g., 17, 18] and the vast body of literature on TAM [e.g., 19, 20], we adopt Individual Background as a generic construct in our model. This construct is operationalized as a composite of three attributes: gender, age, and academic level. Given the exploratory nature of our study, we postulate that individual background might exert an influence on students' beliefs and attitudes toward dHealth technologies. This forms the basis for Hypotheses 1 and 2.

According to TAM, Facilitating Conditions are likely to influence medical students' behavioral intentions. Indeed, Facilitating Conditions influence an individual's perceptions of how difficult the performance of a certain task is [19-21]. In the present study, Facilitating Conditions are operationalized as students' prior experimentations with dHealth technologies during their academic journey. We first posit that increased exposure of medical students to dHealth technologies within medical schools enhances their understanding of the benefits and capabilities of such innovations. Consequently, this heightened comprehension is expected to foster a greater perception of usefulness. Similarly, expanded opportunities for medical students to engage with dHealth technologies, particularly AI applications, are anticipated to bolster their beliefs in the positive impact of AI on the medical field and their own medical practice. Finally, we posit that a higher level of experience with dHealth technologies during medical education correlates with a greater intention among students to integrate dHealth technologies into their future practice. These propositions align with Hypotheses 3, 4, and 5.

As mentioned above, our model includes Perceived Usefulness, another important component of TAM. It is broadly defined as the extent to which individuals believe that the adoption of a technology would improve their performance. In the present study, Perceived Usefulness is adapted to refer to medical students' perceptions of the relevance of integrating dHealth into the medical curriculum. Hypothesis 6 posits that the stronger the belief of medical students that they should receive dHealth training as an integral part of their medical training, the more likely it is that they will have the intention to incorporate dHealth technologies into their future medical practice.

Our second theoretical foundation is Triandis' theory of interpersonal behavior [22]. This theory posits that the behavioral intentions of individuals are shaped by their beliefs about the behavior. Triandis defines belief as an individual's assessment of an object of interest. It is important to note that for Triandis, belief is not necessarily shaped by value judgements about goodness or badness. Instead, it consists of assessments of the existence or absence of certain attributes. For example, an individual might hold the belief that, as a general rule, technology contributes to the advancement of society. In our study, we operationalized medical students' beliefs about AI-related technologies specifically, rather than beliefs involving a broader assessment of dHealth technologies. The specificity of this operationalization stems from the recognition that AI-based tools hold immense potential to transform and enhance the practice of medicine [23, 24]. Hypothesis 7 posits that the more medical students believe in the positive impact of AI on the field of medicine and on their own medical practice, the more likely it is that they will have the intention to integrate dHealth technologies into their future medical practice. The theoretical model is shown in Figure 1.

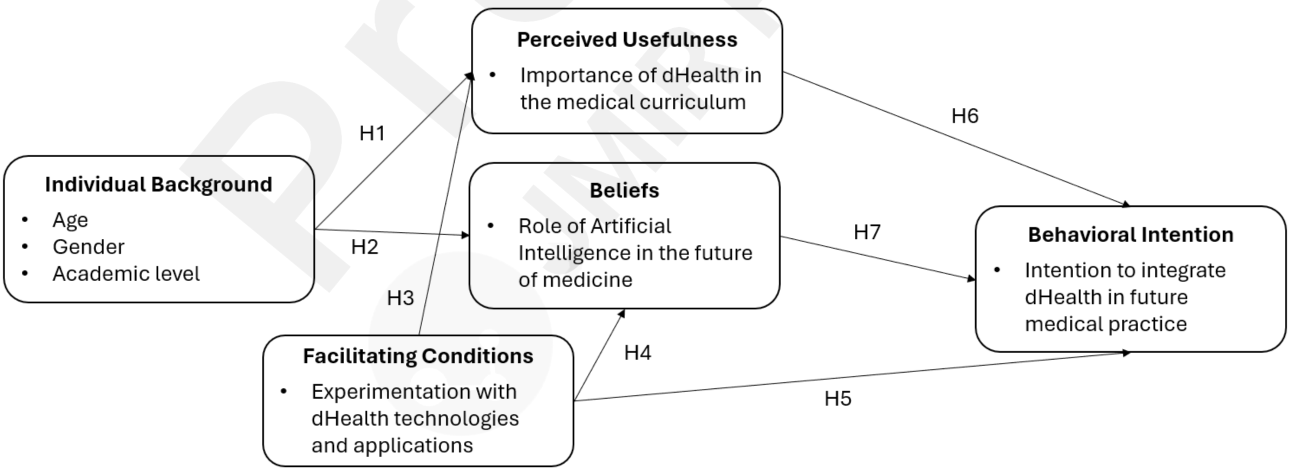

Figure 1. Theoretical Model

Methodology

Setting and Participants

The present study was conducted at a large medical school in Canada. The medical school offers a 5-year long undergraduate medical curriculum. Notably, there is no formal dHealth training provided to the students as part of the standard curriculum. However, students have access to an online training platform that offers educational content on various subjects, including clinical information systems. Additionally, workshops on mobile health and electronic medical records (EMR) are mandatory for students during their clerkship, a stage in their medical education where they gain practical experience and may experiment with different dHealth technologies. Furthermore, the medical school covers issues related to the use of social media, email, and mobile applications by healthcare professionals in elective seminars.

The study population consisted of 1,462 medical students. It comprised two phases of a survey questionnaire: an initial survey (t_0) in February 2020, conducted before the COVID-19 pandemic, and a replication survey (t_1) in May 2023, which took place after the pandemic. The survey was distributed to all students through the medical school's mailing list and was also promoted by the medical student association via its newsletter. There was no incentive for students to fill out the online questionnaire and there were no negative consequences if students did not participate. The survey was developed and administered using the Qualtrics survey platform. The study design and survey instrument were approved by the medical school's ethics committee. Informed consent was obtained from all participants.

Questionnaire development

No existing questionnaire suitable for assessing the variables included in our research model was found. We therefore decided to develop our instrument. Our survey underwent multiple rounds of refinement, further developing the survey items at each round to align with similar survey instruments previously validated in related contexts [e.g., 19]. Our instrument was ultimately validated through assessment by a panel of 10 medical students, who were not included in the sample for the main study. The final survey questionnaire consisted of 70 five-point Likert questions and 8 yes/no items and is available in Multimedia Appendix 1.

Statistical Analyses

Burton-Jones et al. [25] and Levallet et al. [26] emphasize the value of integrating complementary research methods, analytic approaches, and theoretical perspectives (MAPs) to better understand IS phenomena. Our study considers both variance and systems perspectives. The variance perspective focuses on individual variables, while the systems perspective considers the holistic interplay of factors, excluding the process perspective due to its irrelevance to our conceptualization [25]. We applied correlational approaches using structural equation modeling (SEM) and configurational approaches using fuzzy-set qualitative comparative analysis (fsQCA) as outlined by Levallet et al. [26]. To ensure consistency, we gathered data via a survey methodology, allowing us to apply both analytical approaches to the same dataset.

The survey data were first analyzed with descriptive statistics and T-tests. Partial least squares (PLS) SEM has emerged as a prevalent tool for examining exploratory structural models akin to ours. In this study, we employed SmartPLS v4 to test our model [27]. To ascertain the significance levels of the various structural models, we adopted a bootstrapping method, resampling 10,000 times as per the guidelines delineated by Hair et al. [28]. This approach entailed the random selection of subsamples, facilitating robust testing of model parameters.

We then analyzed the same dataset with fsQCA, using the ‘QCA’ package (v4.2.3) on the R platform, which involves three steps: data table construction, truth table construction, and logical reduction [29]. First, raw data is calibrated into set membership scores. The truth table then shows configurations and their outcomes, which are logically reduced to simplify the solution. Consistency and coverage are key concepts in fsQCA evaluation. Consistency measures how well a condition or combination of conditions predicts an outcome, ranging from 0 to 1. We used a raw consistency threshold of 0.80, a frequency threshold of 3, and a proportional reduction in inconsistency (PRI) threshold of 0.50 [30]. Coverage indicates the empirical relevance of a configuration, also ranging from 0 to 1. Consistency is akin to significance in correlational analysis, while coverage is akin to R-squared. Conditions can be core (stronger causal relationship) or peripheral based on their impact on the outcome.

Results

Demographic and descriptive statistics

In the initial survey conducted at time point t_0, 184 students participated, representing a 13% response rate. At time point t_1, for the subsequent survey, 177 students responded, accounting for a 12% participation rate. As detailed in Table 1, the majority of participants were female, constituting 65% at t_0 and increasing to 75% at t_1. The respondents’ average age was 23 years, aligning with the median age of medical students at the university where the study was conducted. While the participant distribution across the first to fifth years of medical training was balanced at t_0, the representation of students in their fourth and fifth years was comparatively lower at t_1.

Table 1. Profile of the Respondents

		Pre-COVID-19 t_0 (n=184)		Post-COVID-19 t_1 (N=177)	
		N	%	N	%
Academic level	Preparatory year	40	22%	38	22%
	First year preclinical	36	20%	75	42%
	Second year preclinical	43	23%	32	18%
	First year clerkship	33	18%	18	10%
	Second year clerkship	32	17%	14	8%
Gender	Female	119	65%	124	70%
	Male	65	35%	51	29%
	Prefer not to respond	0	0%	2	1%

Age	Mean	22.9	22.8
	Standard deviation	3.5	3.3
	Minimum	18	18
	Maximum	38	38

Differences between medical students' views and intentions at t_0 and t_1

As shown in Table 2, most medical students reported limited opportunities to engage with dHealth technologies, including hospital IT, telehealth, mobile applications, and AI technologies during their medical education. Secondly, the overwhelming majority of participants agreed that dHealth education should be a mandatory component of medical training. Medical students prioritized learning about hospital IT, telehealth, and AI technologies, in that order of importance. Thirdly, there was a notable increase in positive attitudes towards AI technologies among students at both initial (t_0) and follow-up (t_1) assessments. Fourthly, most participants expressed a desire to incorporate dHealth in their future medical practice, particularly in areas of patient communication, monitoring, follow-up, and in the prevention, diagnosis, and treatment of diseases.

When comparing the two student groups (t_0 and t_1), t-test analyses revealed significant differences in most of our research variables between t_0 and t_1. In the replication study (t_1), students reported more experience with telehealth and AI technologies than in the initial survey (t0). However, their usage of mobile apps and health IT did not change, potentially due to the reduced participation of fourth- and fifth-year students at t_1 compared to t_0. The heightened interest in telehealth and AI education at t_1 could be attributed to the rise of telemedicine during the COVID-19 pandemic [31] and the increasing prominence of Generative AI tools like ChatGPT [32]. This may explain students' increased intention to adopt dHealth in their medical practice.

Table 2. Comparison of Medical Students' Views and Intentions (t_0 vs. t_1)

Research construct	Pre-COVID-19 t_0 (n=184)	Post-COVID-19 t_1 (N=177)	T-test (two-tailed)
	Mean	Mean	
Individual Background			
Age	22.9	22.8	2
Gender	0.65	0.71	-0.9
Academic level	2.9	2.4	3.642***
Experimentation with dHealth technologies			
Hospital IT systems	1.8	1.8	0.3
Telehealth applications	1.2	1.6	-6.274***
AI-related technologies	1.3	1.5	-3.636***

Mobile applications	1.4	1.4	0.3
Importance of dHealth in medical curriculum			
Hospital IT systems	4.1	4.2	-2.222**
Telehealth applications	3.5	4.1	-6.893***
AI-related technologies	3.5	3.7	-1.7
Role of AI in the future of medicine			
On the medical profession	3.6	3.7	-2.06**
On various medical specialties	3.4	3.5	-2.056**
On one's own medical practice	3.9	4.8	-2.644***
Intent to integrate dHealth in medical practice			
Patient communication and consultation	3.4	4.2	-8.5***
Patient monitoring and follow-up	3.3	4	-6.793***
Disease prevention, diagnosis, treatment	3.6	4.2	-5.485***
** P < 0.05; *** P < 0.001			

Variance Perspective Results

Measurement model

The measurement instrument's psychometrics properties were assessed as a first step in the PLS analysis, confirming the reliability and validity of the instrument's items and scales. The variance inflation factors (VIF) of all our variables for both the structural and measurement models (inner model and outer model, respectively) are less than 2, showing that multicollinearity is not an issue in the present study [28, 33]. Reliability coefficients were all above the minimum acceptable of 0.60 for exploratory research [34]. Analysis of the external loadings shows that the indicators are all above 0.70, which supports the good representation of the indicators in their constructs (available upon request). Last, the square roots of the shared variance between constructs and their measures were higher than the correlations between constructs (available upon request).

Causal analyses

Causal analysis at t_0: Individual background is not significantly linked to Importance of dHealth and Role of AI in the future of medicine. These findings do not support H1 and H2 and suggest that medical students' perceptions are more driven by factors related to technology acceptance models than demographic characteristics like age, gender, or academic level. One of these factors is Facilitating Conditions which are positively and significantly related to Importance of dHealth, Role of AI in the future of medicine, and Intention to integrate dHealth in medical practice. These results confirm H3, H4, and H5. Concerning the other two factors impacting Intention to integrate dHealth, namely Importance of dHealth in the curriculum and Role of AI in the future of medicine, we found that both have a positive and significant impact, confirming

H6 and H7.

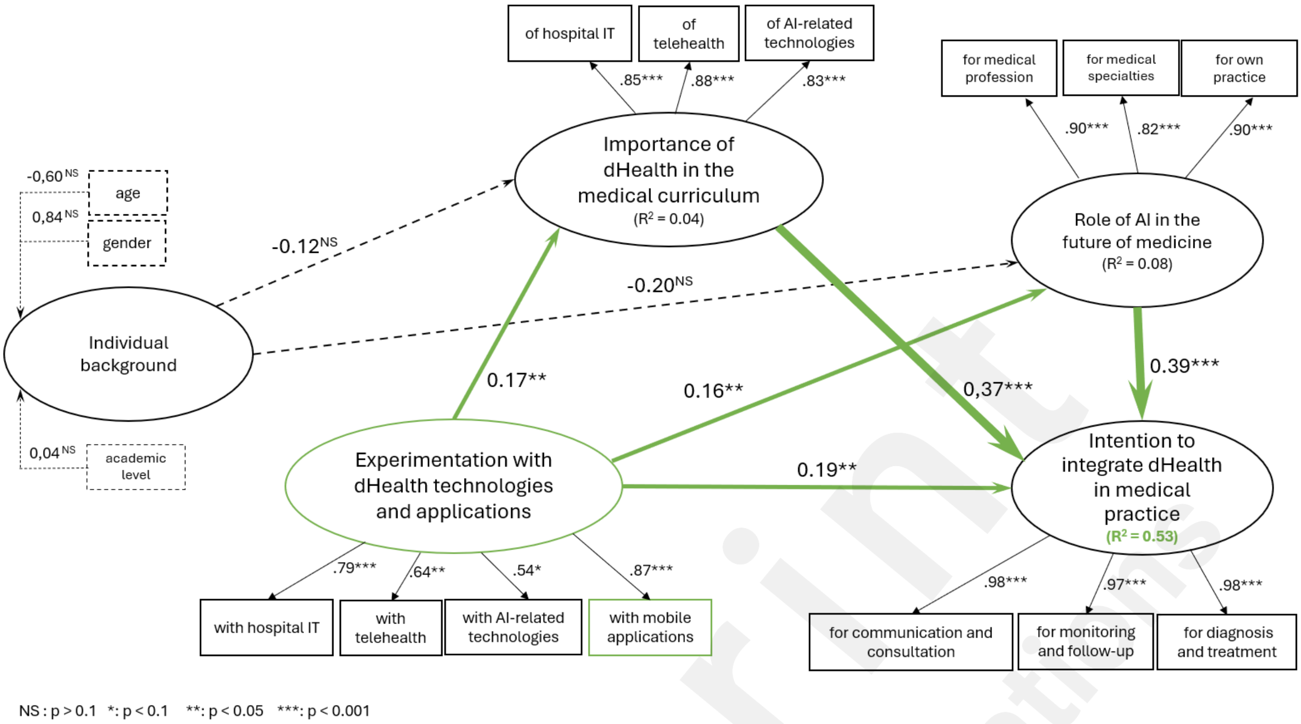

Figure 2. Pre-COVID-19 PLS Results

Causal analysis at t_1: The relationships between Individual background and both Importance of dHealth and Role of AI in medicine are not significant, contradicting H1 and H2. Conversely, Experimentation with dHealth is only positively and significantly related to Role of AI in the future of medicine. This confirms H4 but contradicts H3 and H5. Additionally, Importance of dHealth in the curriculum and Role of AI in future medicine both exhibit a positive and significant influence on Intention to integrate dHealth in future medical practice, confirming H6 and H7.

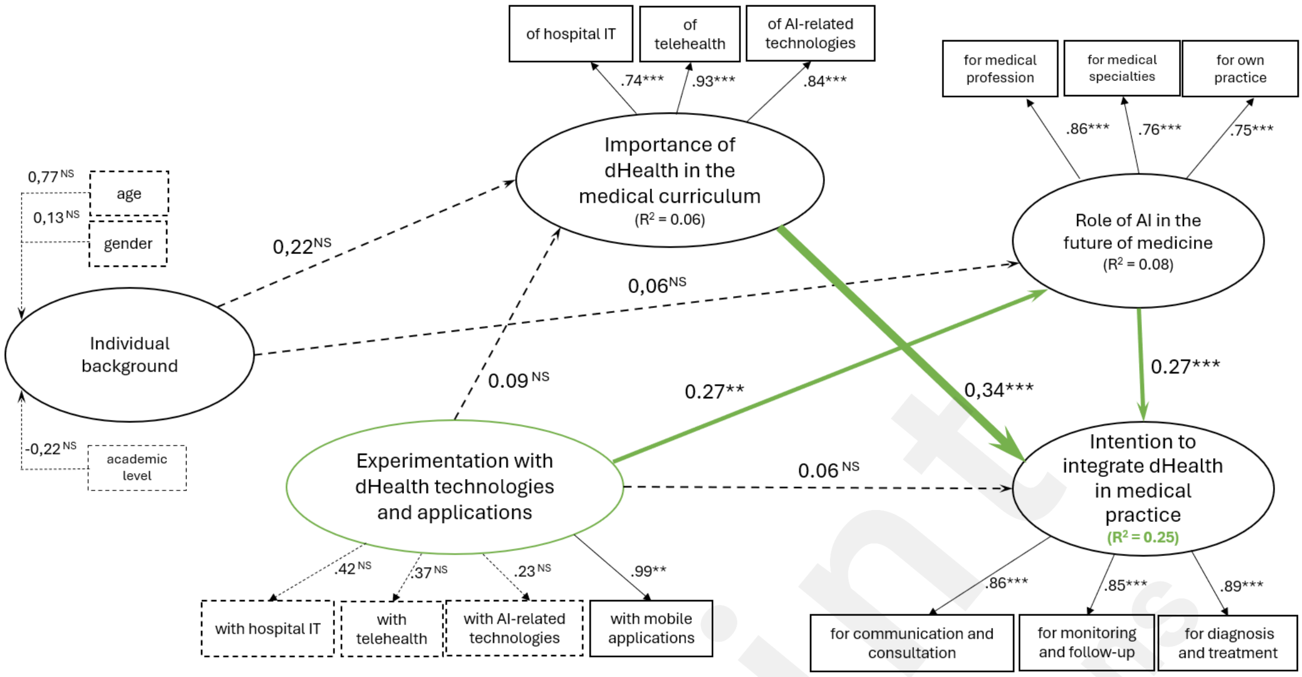

Figure 3. Post-COVID-19 PLS Results

Globally, the relationships hypothesized in our model explain respectively 53% at t_0 and 25% at t_1 of the variance in medical students' intention to integrate dHealth in medical practice (R^2). Table 3 presents a comparative summary of the causal analysis results at t_0 and t_1.

Table 3. Comparative Results at t_0 and t_1

Hypothesis	Confirmation		Coefficient of causality	
	t_0	t_1	t_0	t_1
H1			-0.12NS	0.22NS
H2			-0.20NS	0.06NS
H3	√		0.17**	0.09NS
H4	√	√	0.16**	0.27**
H5	√		0.19**	0.06NS
H6	√	√	0.37***	0.34***
H7	√	√	0.39***	0.27***
NS: Not Significant; ** P < 0.05; *** P < 0.001				

Configurational Perspective Results

Configurational model

Before conducting the configurational analysis (of sufficient conditions), we performed an analysis of necessary conditions with fsQCA to identify any univariate conditions essential for producing the outcome. An element is considered a candidate for a necessary condition if its set membership value is consistently equal to or higher than the set membership value in the outcome. We set a threshold of 0.90 consistency to determine necessity [30, 35] , though above 0.80 with equally high coverage can also be considered a candidate.

Before COVID, the role of AI in the future of medicine had the highest consistency (0.801) and coverage (0.887) for "High Intention" to integrate dHealth in medical practice. The importance of dHealth in the medical curriculum also showed high consistency (0.736) and coverage (0.705). Other elements like experimentation with dHealth technology, academic level, and gender had lower values. After COVID, experimentation with dHealth technology and apps had the highest consistency (0.697) and coverage (0.755). The role of AI maintained high consistency (0.789) and coverage (0.854), while the importance of dHealth in the curriculum remained significant with consistency (0.643) and coverage (0.778). Academic level and gender continued to show lower but consistent values compared to pre-COVID results. Detailed results of the analysis of necessary conditions are available in Multimedia Appendix 2. Overall, these results highlight that the significance of certain conditions, particularly the role of AI and the importance of dHealth, remained notable both before and after COVID. Additionally, the emphasis on experimentation with dHealth technology and apps increased post-COVID, supporting the need for further analysis using fsQCA to explore complex causal relationships among these conditions.

For the configurational analysis with fsQCA, we examined the different combinations of Individual background, Importance of dHealth in the medical curriculum, Experimentation with dHealth technologies and applications, and Role of AI in the future of medicine, that is, the sufficient conditions for medical students to have a high Intention to integrate dHealth in their future medical practice.

Pre-COVID-19 fsQCA results

Table 4. Configurations for the presence and absence of a high intention to integrate dHealth in future medical practice at t_0 (n = 184)

Configuration Configurational element	High Intention			Non-High Intention	
	HI1$_{pre}$	HI2$_{pre}$	HI3$_{pre}$	NHI1$_{pre}$	NHI2$_{pre}$
Facilitating Conditions					
Experimentation with					

dHealth tech. & apps					
Perceived Usefulness					
Importance of dHealth in med. curriculum					
Beliefs					
Role of AI in the future of medicine					
Individual Background					
Academic level					
Gender					
Condition tested					
Consistency	0.93	0.93	0.88	0.75	0.90
Raw coverage	0.31	0.32	0.27	0.16	0.21
Unique coverage	0.08	0.17	0.19	0.16	0.21
Overall solution consistency	0.90			0.83	
Overall solution coverage	0.67			0.37	

Legend. ● : presence of a core condition ● : presence of a peripheral condition
○ : absence of a core condition ○ : absence of a peripheral condition
blank: immaterial condition ("don't care")

Nota. Intermediate solutions (consistency threshold = 0.80, frequency threshold = 3)

The fsQCA results (table 4) show the configurations leading to high and non-high intentions to integrate dHealth in medical practice before COVID. The analysis reveals that before COVID (pre), the role of AI in the future of medicine consistently appears as a core condition across all high intention configurations ($HI1_{pre}$, $HI2_{pre}$, $HI3_{pre}$), with consistency values of 0.934, 0.927, and 0.884, respectively. Additionally, the importance of dHealth in the medical curriculum also plays a significant role, either as a core or peripheral condition, with relatively high consistency values of 0.736 and 0.705. Experimentation with dHealth technologies appears as a peripheral condition in all high intention configurations, while academic level shows up as a peripheral condition in $HI1_{pre}$ and $HI3_{pre}$ but is absent in $HI2_{pre}$.

For non-high intention configurations ($NHI1_{pre}$, $NHI2_{pre}$), gender appears as a core condition in $NHI1_{pre}$, with a consistency of 0.754, suggesting that it is a significant determinant of non-high intention. The importance of dHealth in the medical curriculum appears as a core condition in $NHI2_{pre}$, with a consistency of 0.897, but in a different context compared to high intention configurations. The role of AI in the future of medicine appears as a peripheral condition in $NHI2_{pre}$.

These results highlight the importance of beliefs about AI's role in medicine for integrating dHealth practices. The consistent presence of role of AI in high intention configurations indicates that such beliefs are crucial for fostering high intentions to integrate dHealth in medical practice. The importance of dHealth in the curriculum and experimentation with technologies are also significant factors, suggesting that both educational emphasis and practical experience are vital. The appearance of gender as a core condition in non-high intention configurations may reflect underlying biases or barriers that need to be addressed to improve dHealth integration. The overall solution consistency and coverage values indicate that the identified configurations are robust and provide substantial explanatory power for both high and non-high intentions to integrate dHealth in medical practice.

Post COVID-19 fsQCA results

Table 5. Configurations for the presence and absence of a high intention to integrate dHealth in future medical practice at t_1 (n = 177)

	High Intention						Non-High Intention		
Configuration / Configurational element	HI1a post	HI1b post	HI1c post	HI2a post	HI2b post	HI3 post	NHI1 post	NHI2 post	NHI3 post
Facilitating Conditions									
Experiment. with dHealth tech. & apps									
Perceived Usefulness									
Importance of dHealth in medical curric.									
Beliefs									
Role of AI in the future of medicine									
Individual Background									
Academic level									
Gender									
Condition tested									
Consistency	0.88	0.85	0.86	0.81	0.76	0.77	0.95	0.96	0.94
Raw coverage	0.57	0.45	0.56	0.34	0.28	0.23	0.63	0.33	0.09
Unique coverage	0.07	0.05	0.04	0.04	0.03	0.00	0.25	0.02	0.02

Overall solution consistency	0.80	0.94
Overall solution coverage	0.74	0.66
Legend. ● : presence of a core condition • : presence of a peripheral condition ○ : absence of a core condition ○ : absence of a peripheral condition blank: immaterial condition ("don't care") *Nota*. Intermediate solutions (consistency threshold = 0.80, frequency threshold = 3)		

The after COVID (post) configurational results are presented in table 5. For high intention configurations ($HI1a_{post}$, $HI1b_{post}$, $HI1c_{post}$, $HI2a_{post}$, $HI2b_{post}$, $HI3_{post}$), the most notable elements are the role of AI in the future of medicine and the importance of dHealth in the medical curriculum. The role of AI in the future of medicine appears consistently as a core condition in multiple configurations ($HI1b_{post}$, $HI1c_{post}$, $HI2b_{post}$), with consistency values ranging from 0.763 to 0.848. The importance of dHealth in the medical curriculum appears as both a core and peripheral condition in various configurations, with notable consistency values of 0.883 and 0.855. Experimentation with dHealth technologies is a core condition in the HI1a_p configuration, with a consistency of 0.883 and a raw coverage of 0.573.

For non-high intention configurations ($NHI1_{post}$, $NHI2_{post}$, $NHI3_{post}$), the role of AI in the future of medicine and the importance of dHealth in the medical curriculum also appear as core and peripheral conditions. The role of AI is a core condition in $NHI2_{post}$, with a high consistency of 0.959 and a raw coverage of 0.627. Gender appears as a core condition in NHI1_post, with a consistency of 0.947 and a raw coverage of 0.245.

These results highlight that the significance of certain conditions, particularly the role of AI and the importance of dHealth in the curriculum, remained notable after COVID. The emphasis on experimentation with dHealth technology and apps also remains significant for high intention configurations. The appearance of gender as a core condition in non-high intention configurations suggests potential underlying biases or barriers that need to be addressed. The overall solution consistency and coverage values indicate that the identified configurations provide substantial explanatory power for both high and non-high intentions to integrate dHealth in medical practice. This supports the need for targeted interventions that emphasize the role of AI and practical experimentation with dHealth technologies to foster higher intentions to integrate dHealth in medical practice.

Discussion

Main findings

This study offers a detailed and straightforward account of why medical students are inclined to integrate dHealth technologies into their future medical practice. It was observed that respondents, particularly those in their early years of medical education, have had limited opportunities to engage with dHealth technologies. This limited exposure can likely be attributed to the fact that during their preclinical phase, students typically lack direct access to clinical information systems used in hospitals. The increased engagement with AI tools and telehealth observed at t_1 may be linked to the pandemic's influence, which necessitated a shift towards virtual care and virtual learning. The gap in hands-on experience with dHealth tools and the newfound familiarity with AI and telehealth during the pandemic underpins the strong consensus among respondents that dHealth training should be an integral component of medical education. Moreover, there is a widespread belief among our respondents in the beneficial role of AI in advancing medicine and various medical specialties. Significantly, a large portion of the respondents expressed a firm intent to integrate dHealth technologies, including AI applications, into their practice, highlighting the perceived importance and future potential of these technologies in medicine.

Our analysis further revealed that factors such as age, gender, and academic level did not show statistically significant associations with the adoption of dHealth technologies among medical students. This suggests that the intention to use dHealth solutions may be influenced more by situational or experiential factors rather than demographic variables. Regarding the influence of the pandemic, our findings show that it has significantly elevated the roles of some dHealth tools within medical training. Indeed, the onset of the pandemic has seemingly modified medical students' perceptions of AI tools and teleconsultation platforms, now regarded as crucial components of medical education. Last, our findings underscore the imperative of integrating digital transformation strategies within medical education. According to Matt et al. [3], successful digital transformation involves strategic considerations across four dimensions: technological utilization, value creation changes, structural modifications, and financial aspects. Our results reveal that medical students recognize the enhanced value that dHealth technologies bring to healthcare delivery, highlighting a shift towards more patient-centered and technologically integrated care processes. Moreover, the pandemic has necessitated structural adaptations within medical training environments, accelerating the incorporation of dHealth tools into curricula. Financial aspects are also pivotal, as the increasing demand for digital competencies suggests investments in educational resources to develop these areas are necessary. By aligning dHealth curriculum enhancements with these transformational dimensions, medical schools can better prepare future physicians to navigate and lead in the digitally evolving healthcare landscape.

Study limitations and suggestions for future research

The study's findings should be cautiously considered due to its limitations. First, the low response rate, the gender disparity, and the sample's limited representativeness of all Canadian medical students restrict the generalizability of our results. Hence, future studies could explore dHealth education in medical schools across Canada and internationally, comparing students' dHealth proficiency, attitudes, and intentions. Second, the low response rate might also be associated with a non-response bias. Third, our research model is based on two theoretical foundations. Future research could expand this model to include factors like social influence and effort expectancy [20] as well as IT-enabled medical knowledge management capabilities [36]. Lastly, we encourage researchers to gather qualitative data through interviews or focus groups to enhance our comprehension of medical students' motivations, concerns, and experiences with dHealth technologies. COVID-19 has significantly impacted medical practitioners, affecting their well-being and mental health [37, 38]. Despite the increasing use of dHealth technologies, there appears to be a limit as physicians still require human interaction, leading to digital fatigue [39]. Future research could also capitalize on this opportunity to explore the tipping point at which the use of dHealth technologies overwhelms medical practitioners, adversely affecting their performance. Lastly, investigating how AI shapes the use of evidence-based medicine presents another promising avenue for future research.

The fsQCA results reveal notable differences in the configurations leading to high and non-high intentions to integrate dHealth in medical practice before and after COVID. Before COVID, the role of AI in the future of medicine consistently appeared as a core condition in high intention configurations, with the highest consistency and coverage values. The importance of dHealth in the medical curriculum also played a significant role, either as a core or peripheral condition, alongside experimentation with dHealth technologies. In contrast, after COVID, the configurations show a shift in emphasis. Experimentation with dHealth technology emerges as a core condition in one of the high intention configurations, reflecting increased importance post-COVID. While the role of AI and the importance of dHealth remain significant, their roles are slightly reconfigured, with the role of AI appearing as a core condition in multiple high intention configurations, and the importance of dHealth showing both core and peripheral roles. Additionally, gender appears as a significant core condition in non-high intention configurations both pre and post-COVID, suggesting persistent underlying biases. The overall solution consistency and coverage values are slightly higher post-COVID for non-high intention configurations, indicating a stronger explanatory power of the identified configurations after the pandemic. These comparisons highlight the dynamic nature of the factors influencing the integration of dHealth practices, emphasizing the evolving importance of practical experimentation and persistent beliefs about AI's role in medicine.

Study contributions and implications

Our results outline the importance of enhancing future physicians' digital literacy, focusing on key dHealth tools such as electronic medical records, clinical decision systems, AI-based tools, basics of programming and cybersecurity, and telehealth. Future doctors should also experience how patient data tracking aids in managing health conditions and communication with health professionals, among others. Medical schools in Canada and abroad are encouraged to form groups including professors, students, and patients to periodically review dHealth training needs, promoting hands-on experience with current and emerging technologies, starting from the preparatory year, is recommended [40]. Medical schools could also facilitate interdisciplinary collaboration through events like hackathons [14, 41]. While there are abundant opportunities, we concur with Aungst and Patel [42] that the availability of faculty and experts to facilitate learning experiences might not match the scale. Integrating dHealth topics into the medical curriculum could pose challenges, leading many medical schools to consider providing specialized tracks, certificates, or potentially adjunctive degrees for interested students. To facilitate such developments, dHealth tracks and programs could be created in partnership with other faculties, such as engineering, computer science, and business schools.

Our findings suggest that medical education must adapt to these shifting dynamics, identified in the QCA analysis. Emphasizing practical experimentation with dHealth technologies should become a priority, reflecting its increased importance in post-COVID configurations. Additionally, addressing underlying biases, such as the significant role of gender in non-high intention configurations, should be part of the strategy to foster a more inclusive approach to dHealth integration. Medical schools must remain agile, continually updating curricula to reflect these changes, and consider more flexible and interdisciplinary training programs that can better prepare future physicians for the evolving dHealth landscape.

Conclusion

This study contributes to a deeper understanding of the factors influencing medical students' intention to adopt dHealth technologies in their future practice. Drawing on a theoretical model, the study pinpoints particular dHealth tools suitable for integration into medical curricula, thereby fostering students' active engagement with these innovations. The study also underscores the necessity for medical schools to enhance their educational strategies and resources concerning dHealth, aligning with the imperative to prepare students adequately for proficient use of dHealth technologies in real clinical environments.

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References

Supplementary Files

Multimedia Appendixes

Survey items.
URL: http://asset.jmir.pub/assets/1ed33ed46d541df6ef75f18cd079c556.docx

Analysis of necessary configurational elements.
URL: http://asset.jmir.pub/assets/bc09cf2b746fab4486a537cc280abe0a.docx