Attitudes towardsapplied technology in healthcare amongst medical trainees: insights from a single-institution survey

Abstract

OBJECTIVE

To better understand the need fortraining in certain principles in healthcare technology by assessing current interest in this area amongst a cohort of medical trainees at different stages of their education and in different disciplines (MD students, MD/PhD (MSTP) students, residents, fellows, graduate/PhD students, and postdocs).

MATERIALS AND METHODS

We conducted a cross-sectional observational study of medical trainees at a large, quaternary academic institution. Participant characteristic data was collected and descriptive statistics were generated to evaluate the association between trainee type, gender, and the year the survey was taken (2020 or Q4 2021), with metrics of interest.

RESULTS

Analysis of 156 respondents showed residents/fellows preferred topical lectures as compared to graduate students/postdocs (75.0% yes versus 39.0% yes, $p<.05$), while graduate students/postdocs preferred intensive workshops as compared to residents/fellows (75.6% yes, 29.2% yes, $p<.05$). MD/MSTP students were more interested in a longitudinal curriculum than

graduate students/postdocs (74.7% yes, 31.7% yes, $p<.05$). MD/MSTP students were more interested in product company creation than residents/fellows (36.3% yes, 0.0% yes, $p<.05$).

DISCUSSION

The results of this study highlight the potential effects of the COVID-19 pandemic on interest in biotech and the different interests across the multidisciplinary healthcare and innovation team. Each group of students has varied interests in training topics and delivery modality.

CONCLUSION

Our study findings support the call for structured integration of healthcare technology training into the curriculum for medical trainees and increased programming at all levels of training.

1. INTRODUCTION

BACKGROUND AND SIGNIFICANCE

The use of digital technology within healthcare is pervasive and rapidly expanding. Due to the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009,there has been swift and widespread adoption of the electronic health record (EHR) in the United States with 9 in 10 hospitals using a government certifiedHER (Colicchio et al., 2019; HealthIt.gov).In one study, 56% of physicians were found to use mobile health (mHealth) apps in their clinical practice(Garfan et al., 2021).“mHealth” is defined as the use of mobile phones and other wireless technology within healthcare(Holman).An estimated 81% of the US population owns a smartphone, enabling a majority of consumers to utilize mHealth apps; common mHealth app domains includebehavior modification (medication adherence, weight management, smoking cessation), wellness management, and electronicpatient portals(Kao & Liebovitz, 2017; Rathbone & Prescott, 2017; Solomon & Rudin, 2020).One report estimates that the worldwide digital health market that encompasses these different areas is estimated to grow froma market valuation of $84.08 billion USD in 2019 to $220.94 billion USD by 2026, apositive indicator of this booming sector(GlobeNewswire, 2021).

Some of the health technologies emerging from this space are part of key solutions to strengthening patient outcomes in an ever-evolving population. Due to the SARS-CoV2 pandemic, we saw the rapid and necessary shift of many medical visits to telehealth to protect the well-being of patients and providers(Garfan et al., 2021). While at the time it was done out of necessity, the use of telehealth has now become a familiar option for many Americans and offers a level of flexibility that was not possible before(Liang et al., 2022; Predmore et al., 2021).

During this period, a critical component of the rapid adoption of telehealth was medical professionals and their ability to seek its implementation in their practice while also having sufficient familiarity to educate their patients on its use(Chike-Harris et al., 2021; Masters, 2017).

Giventhe rapid growth of digital health, training in healthcare technology principles amongst medical trainees is more critical than ever for improved patient care and future digital innovation. Needs-based innovation is an approach to the biodesign process and exposure to healthcare technology developed by Stanford University in 2001, identifying an unmet clinical need first and developing a solution rather than searching for novel innovations of existing products (Steinberger et al., 2017; Wall et al., 2017). Stanford University offers topical lectures, electives, opportunities for internships/externships, its flagship Innovation Fellowship, and more to foster new medical technologies; this program shows what can be achieved with a curriculum that trains students in digital health and innovation and was used as a reference when creating our metrics of interest in this study (Brinton et al., 2013; Wall et al., 2017).

The International Medical Informatics Association has provided a framework for the application of biomedical and health informatics within medical education, emphasizing the need for digital literacy prior to entering the workforce (Bichel-Findlay et al., 2023). However, despite its growing importance, the implementation of a formal curriculum within graduate medical education has not been systematically pursued, in part due to a lack of understanding of trainee interest and paucity of literature on this topic. Digital innovation within healthcare thrives with a multidisciplinary approach (physicians, nurses, researchers, etc.); thus, a foundation of innovation-focused training is vital to enable collaboration and to drive forth innovation (Coiera et al., 2022; Marvel et al., 2018; Pfob et al., 2021).

To our knowledge, no clear framework or standardized guidance exists at a national level yet to guide the implementation of these competencies in medical education curricula(Khurana et al., 2022; Majmudar et al., 2015; Niccum et al., 2017; Tudor Car et al., 2021). In this current study, weseek to better understandthe interestforsuch a curriculum amongst a cohort of medical trainees at different stages of their education and in different disciplines (MD students, MD/PhD (MSTP) students, residents, fellows, graduate/PhD students, and postdocs)at a single institution.Weassessed baseline experience prior to starting their training andcurricular experiences the respondent was interested in receiving in the future to assess needs.We also assessed any differences observed before and after the onset of the SARS-CoV2 pandemic in 2021.

2. MATERIALS AND METHODS

We conducted a cross-sectional observational study of medical trainees across Albert Einstein College of Medicine and Montefiore Medical Center in the Bronx, New York, a large, quaternary academic institution. We used Qualtrics XM, an online survey platform, to gather responses. The anonymized survey link was distributed via an internal email list at Albert Einstein College of Medicine with 1,105 members which included current MD students, MD/PhD (MSTP) students, graduate/PhD students, and postdocs in 2020 and again in the fourth quarter (Q4) of 2021.In addition, the survey was sentto program directors and coordinators at Montefiore Medical Center in Q4 2021 requesting to forward to residents and fellows; the total number of trainees was 1,292. The survey was distributed during 2020 and again inthe fourth quarter (Q4) of2021. The survey was determined to be exempt by the Einstein/Montefiore institutional review board.

Participant characteristic data was collected to evaluate the association between trainee type (MD/MSTP vs. Residents & Fellows vs. Graduate Students & Postdocs), gender, and the year the survey was taken, with several metrics of interest. We provided a list of common curricular experiences and programming derived from the Stanford Biodesign program to assess what the respondent would be interested in: (1) Topical lectures (2) Longitudinal curriculum on healthcare technology/clinical informatics/etc. (e.g. as an option elective) (3) Intensive workshops (e.g. Python) (4) Hackathons (5) Internship/Externships health tech startups, VC firms, device, Pharma, FDA/other agency, etc.) (6) Clinical Research Training Program (CRTP) (7) Research year during medical school with biodesign or other business/entrepreneurial focus (only applicable to MD/MSTP students) (8) Biodesign Training Program/Fellowship (9) Product/company creation with opportunity for spinoffs (10) EHR Database Tutorials (only assessed in 2021).(Wall et al., 2017)The research year metric was excluded from Figure 2 as it is only applicable to MD students.

Descriptive statistics were generated for all metrics across the years 2020 and 2021, gender, and trainee type. Pearson Chi-Square was used to compare differences in metrics between 2020 and 2021 and gender. Pearson Chi-Square wasused to compare across the three trainee types.Pairwise Pearson Chi-Square analyses were conducted between each trainee type across the interest in future curricular experiences metrics with a Bonferroni correction calculated as $\alpha_{new} = \alpha_{original} / n$

= .05 / 24 = .002 to account for multiple comparisons.IBM SPSS Statistics for macOS, Version 29.0 was used to generate all statistics and Figure 1. GraphPad Prism for macOS, Version 9.5.1 was used to generate Figure 2.

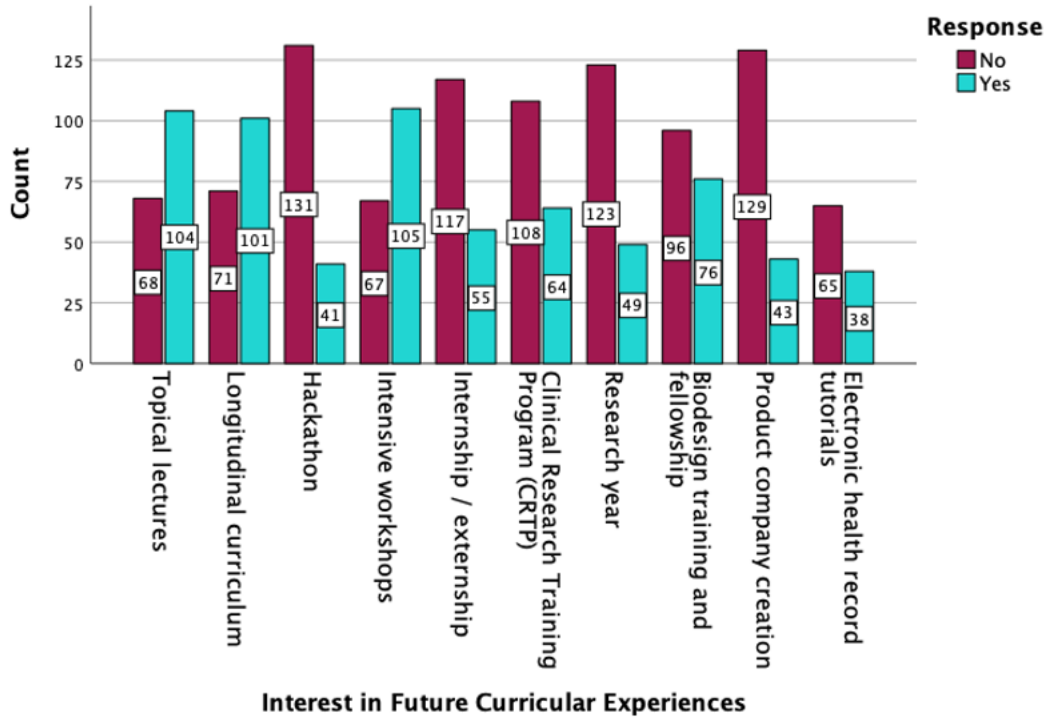
3. RESULTS

There was a total of 156 respondents across 2020 (n=69) and 2021 (n=87) (Table I). 55% (n=86) of respondents were female. 49% (n=76) were MD students, 10% (n=15) were MD/PhD students, 15% (n=24) were residents or fellows, and 26% (n=41) were graduate/PhD students or postdocs. The most popular future curricular experience across all trainees surveyedwere “intensive workshops” (67% yes) while the least popular was “hackathon” (16% yes) (Figure 1).

Table I Participant Characteristics

N (%)	**Total (n=156)**
Sex	
Female	86 (55)
Male	70 (45)
Year Surveyed	
2020	69 (44)
2021	87 (56)
Participant Type	
Medical Student (MD)	76 (49)
Pre-Clerkship (MS1/MS2)	47 (62)
Clerkship (MS3/MS4)	29 (38)
MSTP Student (MD/PhD)	15 (10)
Residents & Fellows	24 (15)
Resident	6 (25)
Fellow	18 (75)
Graduate Students & Postdocs	41 (26)
Graduate/PhD Student	22(54)
Postdoc	19 (46)

Fig.1 Overall interest in future curricular experiences



3.1 Outcome Metrics between 2020 and Q4 2021

There were several significantly different outcomes between survey responses in 2020 and 2021 (Table II). The "Residents & Fellows" trainee type was excluded in this analysis due to a lack of survey distribution to this group in 2020. There was increased interest in 2020 in several future curricular experiences: "hackathon" (p=.002), "internship/externship" (p=.001), "biodesign training and fellowship" (p<.001), and "product company creation" (p<.001). The "electronic health record tutorials" category was not assessed in 2020.

Table II Descriptive statistics of MD/MSTP and graduate students/postdocs between 2020 and 2021

	Time Period		
N (%)	**2020 (n=69)**	**2021 (n=63)**	**p-value**
Gender			

Female	36 (52)	37 (59)	.449
Male	33 (48)	26 (41)	
Trainee type			
Graduate Students & Postdocs	17 (25)	24 (38)	.095
MD & MSTP	52 (75)	39 (62)	
Interest in future curricular experiences			
Topical lectures			
No	26 (38)	30 (48)	.249
Yes	43 (62)	33 (52)	
Longitudinal curriculum			
No	27 (39)	24 (38)	.903
Yes	42 (61)	39 (63)	
Hackathon			
No	41 (59)	53 (84)	.002**
Yes	28 (41)	10 (16)	
Intensive workshops			
No	24 (35)	21 (33)	.861
Yes	45 (65)	42 (67)	
Internship / externship			
No	22 (32)	63 (100)	<.001***
Yes	47 (68)	0 (0)	
Clinical Research Training Program (CRTP)			
No	43 (63)	39 (62)	.961
Yes	26 (38)	24 (38)	
Biodesign/business/entrepreneurial research year (MD/MSTP students only)			
No	26 (50)	26 (67)	.112
Yes	26 (50)	13 (33)	
Biodesign training and fellowship			
No	24 (35)	42 (67)	<.001***
Yes	45 (65)	21 (33)	
Product company creation			
No	26 (38)	63 (100)	<.001***
Yes	43 (62)	0 (0)	
Electronic health record tutorials			
No	N/A	41 (65)	N/A
Yes	N/A	22 (35)	

3.2 Outcome Metrics by Gender

Several key differences were observed between female (n=86) and male (n=70) respondents (Table III). Amongst the future curricular experiences, males had significantly more interest in "internship/externship" (p=.037) and "biodesign training and fellowship" (p=.013) as compared to females.

Table III Descriptive statistics by gender

	Gender		
N (%)	**Female (n=86)**	**Male (n=70)**	**p-value**
Interest in future curricular experiences			
Topical lectures			
No	36 (42)	26 (37)	.549
Yes	50 (58)	44 (63)	
Longitudinal curriculum			
No	33 (38)	31 (44)	.455
Yes	53 (62)	39 (56)	
Hackathon			
No	63 (73)	53 (76)	.727
Yes	23 (27)	17 (24)	
Intensive workshops			
No	38 (44)	24 (34)	.209
Yes	48 (56)	46 (66)	
Internship / externship			
No	65 (76)	42 (60)	.037*
Yes	21 (24)	28 (40)	
Clinical Research Training Program (CRTP)			
No	55 (64)	44 (63)	.888
Yes	31 (36)	26 (37)	
Biodesign/business/entrepreneurial research year (MD/MSTP students only)			
No	34 (65)	18 (46)	.067
Yes	18 (35)	21 (54)	
Biodesign training and fellowship			
No	54 (63)	30 (43)	.013*
Yes	32 (37)	40 (57)	
Product company creation			
No	65 (76)	48 (69)	.330
Yes	21 (24)	22 (31)	
Electronic health record tutorials			
No	28 (33)	28 (40)	.136
Yes	22 (26)	9 (13)	
Not asked (2020)	36 (42)	33 (47)	

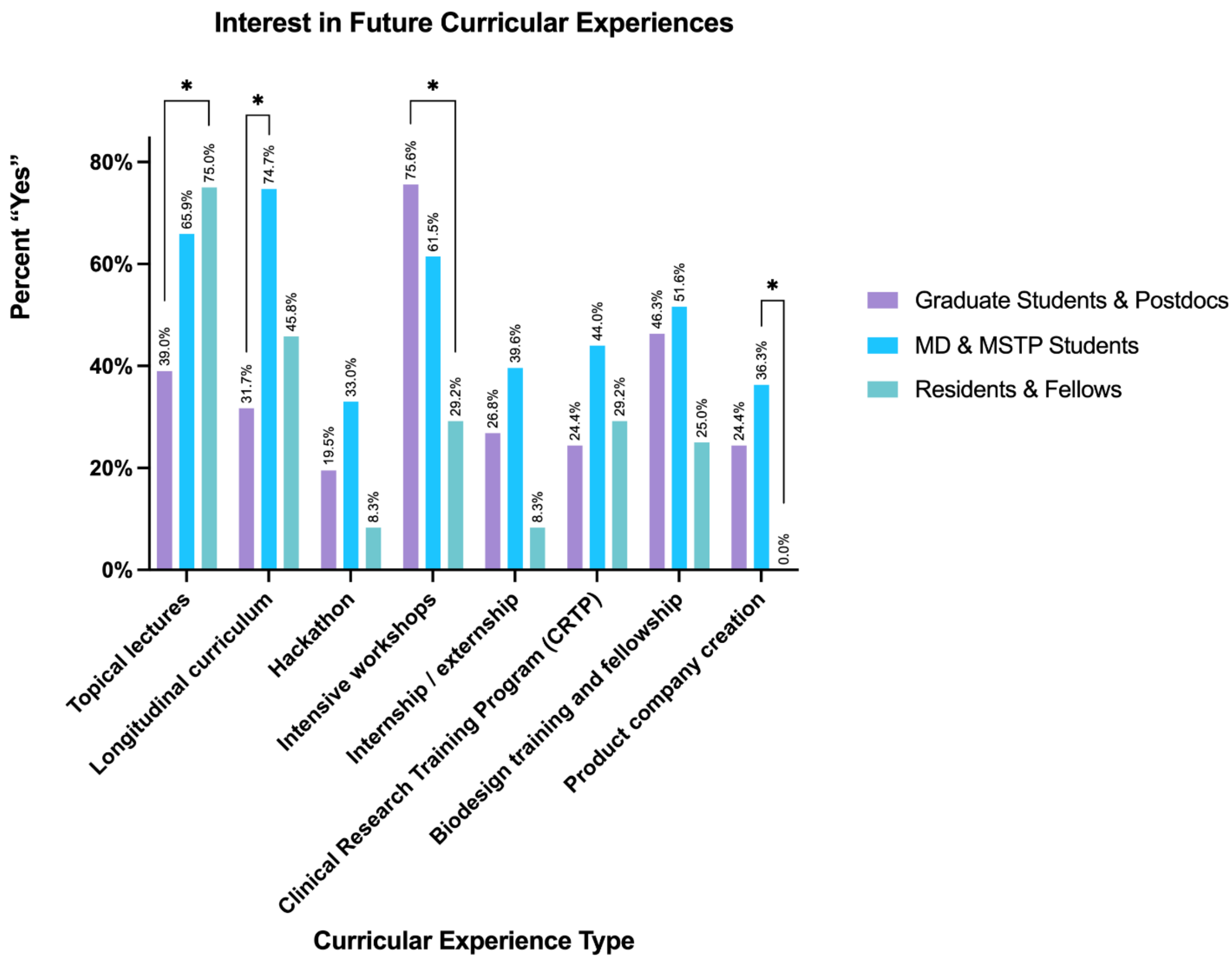
3.3 Outcome Metrics by Trainee Type

Between trainee types (Graduate Students & Postdocs [n=41], MD & MSTP Students [n=91], and Residents & Fellows [n=24]), differences were observed acrossmost metrics (Table IV).

Table IV Descriptive statistics by trainee type

N (%)	**Graduate Students & Postdocs (n=41)**	**MD & MSTP Students (n = 91)**	**Residents & Fellows (n=24)**	**p-value**
Gender				
Female	21 (51)	52 (57)	13 (54)	.412
Male	20 (49)	39 (43)	11 (46)	
Interest in future curricular experiences				
Topical lectures				
No	25 (61)	31 (34)	6 (25)	.004**
Yes	16 (39)	60 (66)	18 (75)	
Longitudinal curriculum				
No	28 (68)	23 (25)	13 (54)	<.001***
Yes	13 (32)	68 (75)	11 (46)	
Hackathon				
No	33 (80.5)	61 (67)	22 (92)	.028*
Yes	8 (19.5)	30 (33)	2 (8)	
Intensive workshops				
No	10 (24)	35 (38.5)	17 (71)	.001***
Yes	31 (76)	56 (61.5)	7 (29)	
Internship / externship				
No	30 (73)	55 (60)	22 (92)	.010**
Yes	11 (27)	36 (40)	2 (8)	
Clinical Research Training Program (CRTP)				
No	31 (76)	51 (56)	17 (71)	.070
Yes	10 (24)	40 (44)	7 (29)	
Biodesign training and fellowship				
No	22 (54)	44 (48)	18 (75)	.066
Yes	19 (46)	47 (52)	6 (25)	
Product company creation				
No	31 (76)	58 (64)	24 (100)	.002**
Yes	10 (24)	33 (36)	0 (0)	
Electronic health record tutorials				
No	23 (56)	18 (20)	15 (62.5)	<.001***
Yes	1 (2)	21 (23)	9 (37.5)	
Not asked (2020)	17 (42.5)	52 (57)	0 (0)	

Fig. 2 Interest in future curricular experiences between trainee types



Amongst graduate students & postdocs, intensive workshops were the most popular future curricular experience (75.6% yes, Figure 2). MD & MSTP students were most interested in a longitudinal curriculum (74.7% yes), followed by topical lectures (65.9% yes). Residents & fellows were most interested in topical lectures (75.0% yes).Across graduate students & postdocs, MD & MSTP students, and residents & fellows, hackathons, internships/externships, and product company creation were the least popular experiences (19.5%/33.0%/8.3% yes, 26.8%/39.6%/8.3% yes, 24.4%/36.3%/0.0% yes).

Several significant differences were observed between trainee types within each curricular experience. Residents & fellows preferred topical lectures as compared to graduate students & postdocs (75.0% yes, 39.0% yes, $p<.001$), while graduate students & postdocs preferred intensive workshops as compared to residents & fellows (75.6% yes, 29.2% yes, $p<.001$). MD & MSTP students were more interested in a longitudinal curriculum than graduate students & postdocs (74.7% yes, 31.7% yes, $p<.001$). Finally, MD & MSTP students were more interested in product company creation than residents & fellows (36.3% yes, 0.0% yes, $p<.001$).

4. DISCUSSION

The survey was distributed throughout 2020 (pre-COVID-19) and during Q4 2021 (during the COVID-19 pandemic).Interest in hackathons, internships/externships, biodesign training and fellowship, and product company creation was significantly lower in 2021. All of these activities traditionally require significant in-person activities, something that was not possible during the time this survey was distributed(Rose, 2020; Wang et al., 2018; Yarmohammadian et al., 2021). The prospect of these being virtual-only may be related to the decreased interest in these specific experiences(Rose, 2020; Wester et al., 2021).Future distributions of this survey as the pandemic subsides are important to determine if this change is transient or lasting.

Historically, female involvement within the Science Technology Engineering and Math (STEM) sector has been lower than males, making up only 28% of the workforce(The Lancet Digital, 2022; Women). This may be due to a multitude of different factors: gender stereotypes, male-dominated cultures, fewer role models, bias, etc.(Women).The current state of women in STEM may also be reflected in our study, influenced by the lack of female representation within this field(Bowman et al., 2022).Female respondents displayed decreased interest in internships/externships and the biodesign training and fellowship, both of which are more long-termcareer-orientedexperiences that may be influenced by their lower sense of belonging and identification with STEM fields(Kricorian et al., 2020; Wall et al., 2017).

Some curricular experiences appealed more to certain trainee categories than others, highlighting the importance of tailoring programming to best match what trainees want(Hopkins et al., 2018; Machleid et al., 2020).While short-form programming like intensive workshops and topical lectures appealed more to graduate students/postdocs and residents/fellowsrespectively (both of which don't have as much of a formal didactic learning), a longitudinal curriculum was more favored by MD/MSTP students. MD/MSTP students' increased interest in product company creation compared to no interest in the residents/fellows surveyed suggests that those that have reached the residency phasemay be less flexible in career shifts or ventures outside of the traditional clinical training pathway(Jubbal, 2018; Tam & Dong, 2021).Part of this may be influenced by the pressure medical students face from the start to focuson the goal of matching into a residency, to veer from this goal during residency after committing so much time to it seems contradictory and could be viewed negatively by the residency program(Tam & Dong, 2021).This finding supports the argument for earlier exposure to healthcare technology, later stages in training offer less flexibility even if a trainee develops interest in this particular area, decreasing the likelihood of an innovation coming to fruition.

This study has several limitations. First, it is subject to selection bias due to its optional nature and method of distribution via email; those who were already interested or involved in this field may have felt more inclined to fill out this survey than those who weren't. Second, our sample size (n=156) is relatively small, which may limit its power.Third,this is a single-center study with a survey distributed at a medical school and hospital system located in the Bronx, New York; thus, its generalizability may be reduced.

Strengths of this study include its diverse inclusion of medical trainees at different stages as well as graduate students and postdocs in healthcare/science related fields that contribute to the multidisciplinary digital health innovation approach, similar representation from both genders that mimics the gender ratio within the US, a wide range of different curricular experiences being assessed, and its ability to assess potential impacts due to the COVID-19 pandemic because of the survey's multiple distribution rounds.

CONCLUSION

It is crucial that the medical trainee curriculum evolves to provide a foundational understanding of different areas of healthcare technology and innovation; this need will only continue to grow with the swift nature of innovation within this space. Recognizing this need and understanding the interest of trainees at all levels and across disciplines is imperative to providing engaging resources that prepare future generations for the emerging digital health landscape.Our study findingssupportthe call for structured integration of healthcare technology training into the curriculum for medical trainees and increased programming at all levels of training.Educators should keep in mind the need to tailor experiences for each phase of training and trainee category when establishinginstructional materials. Earlier exposure to this field is essential for future physicians and scientists to develop a deeper understanding of its strengths, limitations, and areas of improvement that can ultimately lead to better patient outcomes.

DATA AVAILABILITY

The data underlying this article will be shared on reasonable request to the corresponding author.

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