Characteristics of the National Applicant Pool for Clinical Informatics Fellowships (2018-2020)

Douglas S. Bell, MD, PhD[1], Kevin Baldwin, MPH[1], Elijah J. Bell III, MD[1]
[1] David Geffen School of Medicine at UCLA and UCLA Health, Los Angeles, CA

Abstract

In a prior survey, we found that applicants for 2017 ACGME-accredited clinical informatics fellowship positions were only 24% female and only 3% were members of underrepresented minorities (URM, consisting of American Indian or Alaska Native, Black or African American, Hispanic, Latino, or Spanish Origin, or Native Hawaiian or Other Pacific Islander). Since 2018, applications for clinical informatics fellowships have been accepted through the AAMC's Electronic Residency Application Service (ERAS). We analyzed national data from ERAS on applicants to clinical informatics fellowship programs for 2018 to 2020 positions. We also obtained applicants' subsequent success in starting clinical informatics fellowship training from the AAMC's GME Track survey. Over these 3 years, we found that the fellowship applicant pool grew from 63 to 74 (17%) and the number of positions offered grew from 34 to 41 (17%). The proportion of women applicants grew to 34% by 2020 and the proportion of underrepresented minorities grew to 12% by 2020. By comparison, medical students 7 years earlier (2013) were 47% female (P=.01) and 16% URM (P>.20), and applicants to many other subspecialties were similar. Applicants' sex and URM membership were not associated with success in starting fellowship training. We conclude that the underrepresentation of women and URM members in clinical informatics fellowships has improved but not resolved. Urgent efforts are needed to increase the both the numbers and the diversity of clinical informatics applicants by promoting the field among medical students and residents, particularly among women and URM members.

Introduction

In 2014, the Accreditation Council for Graduate Medical Education (ACGME) gave accreditation[1] to the first four fellowship training programs in the subspecialty of clinical informatics.[2] Despite significant funding challenges,[3,4] the number of ACGME-accredited fellowship programs grew to 26 by 2018, and by February, 2022, the American Medical Informatics Association (AMIA) listed 42 accredited programs.[5] This robust growth shows that clinical informatics fellowships have been successful in getting started, but continued success depends on their recruiting sufficient numbers of well qualified candidates, including a diverse gender and minority representation.

In 2018, we published an analysis of surveys that we conducted of clinical informatics fellowship program directors and applicants.[6] We found that the pool of applicants grew by 23% and the number of positions grew by 25% from the 2016 to the 2017 matriculation years. We also found that among applicants for 2017 positions, 24% were female and only 3% were members of underrepresented minority groups. We concluded that greater efforts were needed to promote diversity. In 2021, AMIA and its Community of Clinical Informatics Program Directors (CIPD) successfully implemented a computerized fellowship match program, addressing the most frequent complaint that fellowship applicants expressed in our survey.[7] In addition, CIPD has convened a marketing task force, which is actively investigating options for promoting broader interest in the field. However, these joint activities remain nascent and most marketing for the subspecialty continues to be performed by individual programs.

The current study updates our analysis of applicants to ACGME-accredited clinical informatics fellowship programs nationally. Starting in 2017 (for applications to 2018 positions), clinical informatics fellowship programs accepted applications only through the Electronic Residency Application Service (ERAS) of the American Association of Medical Colleges (AAMC). The use of this service makes it possible to analyze the universe of applicants without the need to mount a voluntary survey. We sought to (1) describe the growth in clinical informatics fellowship positions and applicants during the initial ERAS years, (2) compare the diversity of clinical informatics applicants with the diversity of medical students and applicants to other fellowships, and (3) assess the associations between applicant characteristics and their success or failure in obtaining a fellowship position.

Methods

Data Sources

We abstracted data on applicants to 2016 and 2017 clinical informatics fellowship positions from our previously published surveys of program directors and applicants.[6] In estimating the total applicant pool size for these years, we had postulated low and high boundary values using assumptions of 2–5 applications per unsuccessful fellow. For comparison in this report, we estimated single values based on the midpoint of this range — 3.5 applications per unsuccessful fellow.

We purchased from the AAMC data on each applicant to all clinical informatics fellowship programs nationally for 2018 through 2020 positions. Applicants were included if they applied to any of the 6 clinical informatics subgroups: Clinical Informatics (Anesthesiology), Clinical Informatics (Emergency Medicine), Clinical Informatics (Family Medicine), Clinical Informatics (Internal Medicine), Clinical Informatics (Pathology), and Clinical Informatics (Pediatrics). Programs that did not use ERAS for applications were not included.

To protect individuals' anonymity, AAMC transformed applicants' self-reported race/ethnicity into a single URM_Indicator variable that could take on one of four values. A value of "underrepresented minority" (URM) was used for each U.S. citizen or permanent resident who self-identified as one or more of the following race/ethnicity categories (alone or in combination with any other race/ethnicity category): American Indian or Alaska Native; Black or African American; Hispanic, Latino, or of Spanish Origin; or Native Hawaiian or Other Pacific Islander. A "NON-US" value indicated each applicant who was not a U.S. citizen or permanent resident. A blank URM_Indicator variable indicated applicants who opted to leave their race/ethnicity information blank on the ERAS application. Finally, a value of "No" for URM_Indicator represented U.S. citizens or permanent residents who self-identified as Asian or White race/ethnicity.

AAMC provided the START_YEAR of training if the applicant was reported in the AAMC's GME Track Resident Survey as having started training in one of the Clinical Informatics subspecialties listed above by 2020. Note that response rates on the GME Track Resident Survey are about 95% in each year, so it is possible that a few applicants are misclassified as having failed. Additionally, there were two applicants who succeeded in 2019 after being unsuccessful in 2018, as well as two who succeeded in 2020 after being unsuccessful in 2019. Each application for these individuals was analyzed as a separate instance, unsuccessful in the initial year and successful in the subsequent year. Also included in the data was the applicant's sex, their med school nationality (U.S vs. IMG/Canadian) and degree (MD vs. DO), med school graduation year, the count of programs applied to, and counts of the applicants' research experiences, volunteer experiences, work experiences, and peer reviewed articles that they reported in their applications.

Aggregate data on students who started medical school in 2011-3 (seven years earlier, assuming 4 years' medical school plus three years residency) were also provided by AAMC. Aggregate data on applicants to other fellowship programs were downloaded from the AAMC's ERAS statistics website.[8] We chose 10 subspecialties for comparison, including the 7 most frequently applied-for subspecialties plus pediatric emergency medicine and two surgical subspecialties.

Analysis

We used 2-tailed Fischer's exact tests to compare applicants' gender and URM status across years, to compare clinical informatics applicants vs. other sub-specialty applicants and medical students, and to compare the bivariate influence of applicant characteristics on their success in matriculating to start fellowship training in one of the ACGME-accredited clinical informatics programs. We also tried using logistic regression to analyze multivariate associations of applicant characteristics with success in matriculating to a fellowship but all relationships became insignificant, suggesting that the number of subjects was not sufficient to support logistic regression.

Because the data for this study was entirely anonymous, it was considered non–human subjects research by the UCLA Institutional Review Board.

Results

We received data from ERAS on 194 applications from 190 individuals who applied to start fellowships in 2018 to 2020. We compare results with analyses of 467 *applications* from successful and unsuccessful candidates in our 2016–2017 program director surveys, and 33 candidates who responded to our 2017 applicant survey.

Table 1 describes programs, applicants and applicant characteristics by year. From 2018 to 2020, the number of programs grew from 23 to 31 (30%), the number of positions offered grew from 34 to 41 (17%) and the fellowship applicant pool grew from 63 to 74 (17%). By comparison, the 2018 to 2020 growth in applicants was 19% for pulmonary and critical care, 14% for gastroenterology, 9% for hospice and palliative medicine, 8% for cardiovascular medicine, and 2% for hematology-oncology. Over the full five years, the number of programs grew by 158% (from 12 to 31) whereas the number of positions offered grew by only half as much (71%, from 24 to 41), with the mean number of positions offered per program falling from 2.0 to 1.3. The total number of applicants grew from 50 (estimated) to 74 (48%), and the proportion of applicants who succeeded rose to 55% by 2020. (The success rate was higher in 2019 due to a decrease in the applicant pool that year.)

The proportion of female applicants rose from 24% in 2017 and 2018 and 21% in 2019 to 32% in 2020, but the difference from 2019 to 2020 was not statistically significant (*P*=.17). The proportion of URM applicants also rose from 1% in 2017 and 6% in 2018 to 12% in 2020, but the difference from 2018 to 2020 was not statistically significant (*P*=.55). The proportion of applicants who were not U.S. citizens or permanent residents fell from 27% in our 2017 survey to 5% in 2020, and the difference from 2018 to 2020 trended toward statistical significance (*P*=.08). The proportion of applicants who went to international or Canadian medical schools was 43% in 2018, but in 2019–20 was 24–5%, similar to our prior survey results. The mean count of programs that each applicant applied to remained 9–11 from 2019–20. The mean counts of volunteer experiences, research experiences, work experiences, and peer reviewed articles varied from two to five, with standard deviations roughly equal to means, indicating skewed distributions.

Table 1. Number of ACGME-accredited fellowship programs, positions, applicants, and applicant characteristics, by year, 2016 to 2020

	2016	2017	2018	2019	2020
Number of programs offering positions	12	18	23	28	31
Number of positions filled by all programs (N applicants successful)	24	30	34	35	41
Total fellowship applicant pool	50[1]	61[1]	63	57	74
Proportion of applicants who succeeded	48%[1]	49%[1]	54%	61%	55%
Sex: Female		8 (24%)[2]	15 (24%)	12 (21%)	24 (32%)
Minority status: URM		1 (3%)[2]	4 (6%)	7 (12%)	9 (12%)
No Answer			8 (13%)	5 (9%)	8 (11%)
non-US		9 (27%)[2]	10 (16%)	4 (7%)	4 (5%)
Medical School: International/Canadian		6 (18%)[2]	27 (43%)	14 (25%)	18 (24%)
Mean count of Programs applied to (SD)			9.3 (7.0)	11 (7.7)	8.9 (7.5)
Mean count of Volunteer experiences (SD)			3.3 (3.4)	4.8 (4.6)	5.0 (4.7)
Mean count of Research experiences (SD)			2.0 (2)	2.6 (2.5)	2.9 (2.8)
Mean count of Work experiences (SD)			4.6 (4.3)	4.2 (3.6)	4.6 (3.9)
Mean count of Peer-review articles (SD)			3.2 (4.7)	3.8 (6.5)	3.0 (4.7)

1: Estimate based on median assumption of 3.5 applications per unsuccessful applicant.

2: Estimate based on 2017 applicant survey, n= 33 respondents

Table 2 shows that by 2020, women were still significantly underrepresented among clinical informatics applicants compared with medical students in the class starting seven years earlier (32% vs. 47%, *P*=.01). However, the degree of female under-representation was similar to many other subspecialties. Among the ten subspecialities we examined, cardiovascular and pain medicine had significantly lower female proportions than clinical informatics; hematology-oncology, hospice & palliative medicine, child and adolescent psychiatry, and pediatric emergency medicine had higher female proportions, and pulmonary & critical care, gastroenterology, colon and rectal surgery and thoracic surgery had similar proportions.

Compared with 2013 medical students, the proportion of URM individuals among clinical informatics applicants was lower (12% vs. 16%) but this 33% deficit was not statistically significant (*P*>.20). Proportions of URM applicants were also similar for all other subspecialties except child and adolescent psychiatry, which was higher than clinical informatics (25% vs. 12%, *P*=.02). The proportion who chose not to answer the race/ethnicity question was higher among clinical informatics applicants (11%) than any other subspecialty and higher than 2013 medical students, but the differences were statistically significant only for pulmonary and critical care, colon & rectal surgery, and thoracic surgery.

Table 2. Comparison of Sex and Race-ethnicity among 2020 clinical informatics applicants vs. other 2020 fellowship applicants and 2013 medical students.[1]

Program	Total N	Female (%)	*P*	URM (%)	*P*	No Answer (%)	*P*
Clinical informatics	74	24 (32%)		9 (12%)		8 (11%)	
Cardiovascular medicine	1594	362 (23)	.07	170 (13)		96 (7.4)	
Pulmonary & critical care	1295	435 (33)		131 (12)		58 (5.5)	.07
Gastroenterology	1048	373 (36)		120 (13)		80 (8.6)	
Hematology-oncology	909	405 (45)	.05	77 (10)		44 (5.8)	
Pain medicine	514	101 (20)	.02	63 (13)		34 (6.7)	
Hospice & palliative medicine	453	272 (60)	<.0001	48 (11)		21 (5.0)	
Child and adolescent psychiatry	373	206 (55)	<.001	98 (25)	.02	28 (7.2)	
Pediatric emergency medicine	266	178 (67)	<.0001	38 (15)		19 (7.3)	
Colon and rectal surgery	163	62 (38)		21 (13)		4 (2.1)	.02
Thoracic surgery	146	39 (27)		23 (17)		6 (4.4)	.09
2013 Medical Students		9467 (47)	.01	3168 (16)		1393 (6.9)	

1: *P* values represent 2-tailed Fischer exact tests comparing counts of clinical informatics applicants (first row) versus other fellowship applicants or medical students. Only *P* values < .20 are shown. Percentages highlighted in green are significantly higher compared with clinical informatics; those highlighted in grey are significantly lower compared with clinical informatics.

Table 3 shows application characteristics that were and were not significantly associated with success in matriculating to a fellowship position. Importantly, applicant sex and URM membership were not significantly associated with success. However, applicants who attended a foreign or Canadian medical school had an odds ratio (OR) for success of 0.54 and those who were not U.S. citizens or permanent residents had an OR for success of 0.34. Applicants who applied to 11 or more programs had much greater success (OR 3.3) compared with those who applied to 10 or fewer programs. Also, those who were not starting training immediately after residency and those starting more than 6 years after medical school had much less success (ORs 0.51 and 0.30, respectively). There were trends toward greater success rates for applicants who had higher counts of research experiences and volunteer experiences but they were not statistically significant at the P ≤ .05 level. Counts of work experiences and peer reviewed publications were not associated with greater success.

Table 3. Bivariate associations of clinical informatics application characteristics with success in matriculating to start fellowship training, 2018–2021

Characteristic	N (%) of CI applicants	N Success in match	% Success rate	Odds Ratio	*P*-value
Sex: Male	143	79	55%		
Female	51 (26%)	31	61%	1.3	.49
Med School: US MD or DO	135	83	61%		
IMG/Canadian	59 (30%)	27	46%	**0.54**	**.04**
Minority Status: Non-URM	135	80	59%		
URM	20 (10%)	11	55%	0.85	.71
Non-US	18 (9%)	6	33%	**0.34**	**.04**
No Answer	21 (11%)	13	62%	1.1	.81
Programs applied-to count: 1–10	120 (62%)	55	46%		
11–27	74	55	74%	**3.3**	**.0001**
Start immediately after residency: Yes	98 (57%)	68	69%		
No	73	39	53%	**0.51**	**.04**
Years after medical school: 3–6	132 (68%)	87	66%		
7–29	62	23	37%	**0.30**	**0002**
Research experience count: 0–3	132 (68%)	69	52%		
4–11	62	41	66%	1.8	.07
Volunteer experience count: 0–3	105 (54%)	55	52%		
4–20	89	55	62%	1.5	.19
Work experience count: 0–3	101 (52%)	57	56%		
4–20	93	53	57%	1.0	1
Peer-reviewed articles count: 0–3	141 (73%)	83	59%		
4–36	53	27	51%	0.7	.32

1: *P* values represent 2-tailed Fischer exact tests comparing proportions of clinical informatics applicants who succeeded in obtaining a fellowship position according to the applicant characteristics shown. The percentages highlighted in gray are significantly lower compared with the referent; those highlighted in green are significantly higher.

Discussion and Conclusions

We found that the pool of applicants for ACGME-accredited clinical informatics fellowship positions continued to grow in 2018–2020 but at a rate more similar to those of much larger subspecialties like pulmonary and critical care medicine. Women continue to be underrepresented in clinical informatics, but the level of underrepresentation is now similar to several other subspecialties, and is better than cardiology and pain medicine. Rates of underrepresented minority (URM) participation among clinical informatics applicants were improved from the severe deficit we found in 2016–17, with final rates in 2020 that, due to small numbers, were not statistically different from the comparable medical school class, despite being 1/3 lower. A study of URM representation among 2426 students who were awarded PhD degrees in biomedical informatics from 2002 – 2017 also found a rate of 12%, albeit without any trend toward improvement over time.[9]

Thus, as clinical informatics moves into its early adolescence, rates of female and URM participation among applicants have improved, but parity has not been achieved. In addition, growth in the applicant pool size has decelerated from the earliest years, with a modest decrement in the subspecialty's competitiveness.

Reassuringly, we found that applicant sex and URM membership were not associated with applicants' success in securing a fellowship. As might be expected, applicants who were not U.S. citizens, or who had gone to foreign medical schools were substantially disadvantaged. However we also found unexpectedly high disadvantages for older applicants and those who applied to fewer programs. The lack of any greater success among applicants reporting greater numbers of work experiences or peer-reviewed publications indicates that they contributed less homogeneous value compared with research experiences and volunteer experiences.

The study's main limitations are the relatively small numbers of clinical informatics applicants, which prevented our ability to test multivariable associations, and the aggregation of race/ethnicity values into one URM indicator. The latter limitation makes it impossible to distinguish among the four URM groups, but it is likely that even if the data were disaggregated, any findings would be limited by small numbers. One additional limitation is the nonresponse rate of 5% on the GME Track Residency Survey. If we misclassified 5% of applicants as having failed when they in fact succeeded, then in 2020 the number of fellowship positions would be 2 higher and the acceptance rate would be 58%, 3 percentage points higher.

It should also be noted that our study reflects fellowship selection processes that took place before onset of the global COVID-19 pandemic. Fellows who matriculated in 2020 were interviewed and selected by December 2019, and the first U.S. cases of COVID-19 occurred in January 2020. The COVID-19 pandemic most likely reduced the numbers of programs that candidates applied to, and it certainly affected the operations of each program, but its effect on the number of positions and applicants, and on their diversity remains to be investigated.

Our finding of decelerating growth in the applicant pool indicates that the field of clinical informatics urgently needs robust marketing to enhance interest in clinical informatics careers among medical students and residents, with continued emphasis on women and members of underrepresented minorities. The recent finding that women were significantly underrepresented among informatics leadership and awardees[10] highlights the potential recruitment benefits of increasing the diversity of visible informatics leaders and mentors. Recruitment efforts should also include strong informatics curricular opportunities for medical students and residents. Successful examples of programs aimed at residents include UCLA's Resident Informaticist program, which provides monthly didactics and a mentored informatics project for 16–20 residents per year from a broad diversity of residency programs.[11] An alternative model for informatics education during residency is exemplified by the development of a specialized clinical informatics track within a psychiatry residency, combining informatics service, didactics and research.[12]

A recent survey of medical students in Israel found unexpectedly low levels of interest in information technology and computer science, despite the students' immersion in usage of technology.[13] This finding is consistent with the research that we previously cited, showing less interest in computer science among those with greater commitment to social activism,[14] and greater concerns about lifestyle and family demands.[15] Thus, effective recruitment messaging might emphasize the pro-social benefits that informaticists provide for patients and colleagues, and the controllable lifestyles of informatics professionals.

ACGME recently implemented revised milestones for clinical informatics training to incorporate the results of a rigorous practice analysis,[16] a change that will strengthen all fellowship training programs. However, the recent 3-year extension of the "practice pathway" for clinical informatics board eligibility,[17] which allows individuals who were already practicing informatics to take the certification examination without completing a fellowship, shows that the growth in fellowship positions has not met the demand for board-certified clinical informaticists. The practice pathway was originally scheduled to end after five years and then was extended to 10 years, and now with 3 more years it will end after the 2025 exam cycle. Although a large majority of the 178 clinical informatics board certifications in 2018 had still become eligible through the practice pathway,[18] an open letter to the American Board of Preventive Medicine and American Board of Pathology proposes that an extension will mostly enable certification for individuals who could have engaged in fellowship training but chose not to.[19] Our finding that older applicants are substantially disadvantaged in obtaining fellowship training runs counter to this assertion. Thus, as program directors work to expand interest in clinical informatics fellowship training, it is at least as important to expand funding for an increased number of training positions.

In conclusion, subspecialty fellowships in clinical informatics have grown, and the gender and race/ethnicity disparities are less stark than in 2018, but fellowship programs need to secure funding in support of more accelerated growth, and to redouble their efforts to recruit more well-prepared trainees with greater diversity.

Acknowledgements

Dr. Bell's effort for this project was supported in part by the NIH National Center for Advancing Translational Science (NCATS) UCLA CTSI Grant Number UL1TR001881. We are very grateful to Brianna Gunter at the AAMC for facilitating the preparation of data for this study.

References

1 Safran C, Shabot MM, Munger BS, Holmes JH, Steen EB, Lumpkin JR, Detmer DE, AMIA Board of Directors. Program requirements for fellowship education in the subspecialty of clinical informatics. Journal of the American Medical Informatics Association. 2009 Mar 1;16(2):158-66.

2 Longhurst CA, Pageler NM, Palma JP, Finnell JT, Levy BP, Yackel TR, Mohan V, Hersh WR. Early experiences of accredited clinical informatics fellowships. Journal of the American Medical Informatics Association, 2016; 23(4): 829–834.

3 Kannry J, Smith J, Mohan V, Levy B, Finnell J, Lehmann CU. Policy statement on clinical informatics fellowships and the future of informatics-driven medicine. Applied Clinical Informatics. 2020 Oct;11(05):710-3.

4 Lehmann CU, Longhurst CA, Hersh W, Mohan V, Levy BP, Embi PJ, Finnell JT, Turner AM, Martin R, Williamson J, Munger B. Clinical Informatics Fellowship Programs: In Search of a Viable Financial Model: Anopen letter to the Centers for Medicare and Medicaid Services. Applied Clinical Informatics. 2015 Apr 15;6(2):267-70.

5 https://amia.org/careers-certifications/informatics-academic-programs?search_query=&field_acgme_accredited=1

6 Bell DS, Baldwin K, Bell EJ, Lehmann CU, Webber EC, Mohan V, Leu MG, Hofmann JM, Kaelber DC, Landman AB, Hron J, Silverman HD, Levy B, Elkin PL, Poon E, Luberti AA, Finnell JT, Safran C, Palma JP, Forman BH, Kileen J, Arvin D, Pfeffer M. Characteristics of the National Applicant Pool for Clinical Informatics Fellowships (2016-2017). AMIA Annu Symp Proc. 2018 Dec 5;2018:225-231. PMID: 30815060; PMCID: PMC6371309.

7 Pageler NM, Elkin PL, Kannry J, Leu MG, Levy B, Lehmann CU. A Clinical Informatics Program Directors' Proposal to the American Board of Preventive Medicine. Applied Clinical Informatics. 2020 May;11(03):483-6.

8 https://www.aamc.org/data-reports/interactive-data/eras-statistics-data Accessed 2/26/2022.

9 Wiley K, Dixon BE, Grannis SJ, Menachemi N. Underrepresented racial minorities in biomedical informatics doctoral programs: graduation trends and academic placement (2002–2017). Journal of the American Medical Informatics Association. 2020 Nov 1;27(11):1641-7.

10 Griffin AC, Leung TI, Tenenbaum JD, Chung AE. Gender representation in US biomedical informatics leadership and recognition. Journal of the American Medical Informatics Association. 2021 Jun;28(6):1270-4.

11 Singer JS, Cheng EM, Baldwin K, Pfeffer MA, UCLA Health Physician Informaticist Committee. The UCLA health resident informaticist program–a novel clinical informatics training program. Journal of the American Medical Informatics Association. 2017 Jul 1;24(4):832-40.

12 Vitiello E, Kane M, Hutto A, Hall A. Building for the future: the creation of a residency training track to foster innovation through clinical informatics in psychiatry. Journal of the American Medical Informatics Association. 2020 Nov 1;27(11):1747-51.

13 Avidan A, Weissman C, Zisk-Rony RY. Interest in technology among medical students early in their clinical experience. International journal of medical informatics. 2021 Sep 1;153:104512.

14 Sax LJ, Lehman KJ, Jacobs JA, Kanny MA, Lim G, Monje-Paulson L, Zimmerman HB. Anatomy of an enduring gender gap: the evolution of women's participation in computer science. The Journal of Higher Education. 2016;88(2):258-293.

15 Riska E. Gender and medical careers. Maturitas. 2011 Mar;68(3):264-7.

16 Silverman HD, Steen EB, Carpenito JN, Ondrula CJ, Williamson JJ, Fridsma DB. Domains, tasks, and knowledge for clinical informatics subspecialty practice: results of a practice analysis. Journal of the American Medical Informatics Association. 2019 Jul;26(7):586-93.

17 The American Board of Preventive Medicine Announces a Three-Year Extension of the Practice Pathway for Clinical Informatics Available at: https://www.theabpm.org/2022/03/02/the-american-board-of-preventive-medicine-announces-a-three-year-extension-of-the-practice-pathway-for-clinical-informatics/

18 Desai S, Mostaghimi A, Nambudiri VE. Clinical informatics subspecialists: characterizing a novel evolving workforce. Journal of the American Medical Informatics Association. 2020 Nov 1;27(11):1711-5.

19 Turer RW, Levy BP, Hron JD, Pageler NM, Mize DE, Kim E, Lehmann CU. An Open Letter Arguing for Closure of the Practice Pathway for Clinical Informatics Medical Subspecialty Certification. Applied Clinical Informatics. 2022 Jan;13(01):301-3.