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Virtual Education for Patient Self-Testing for Warfarin Therapy Is Effective During the COVID-19 Pandemic

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Background: Prior to the COVID-19 pandemic, warfarin users were required to complete in-person training in order to participate in approved international normalized ratio (INR) patient self-testing (PST) programs. To minimize in-person contact during the pandemic, a federal waiver of the in-person training requirement allowed new patients to begin PST after completing virtual training. However, it was uncertain whether such patients achieved comparable levels of INR control to patients receiving in-person training.

Methods: INR results for patients receiving virtual training upon PST commencement between April 1, 2020, and December 31, 2020, were compared to those of patients initiating PST with in-person training between April 1, 2019, and December 31, 2019. The primary outcome was the difference in warfarin time in therapeutic range (TTR) between the groups, with secondary outcomes including differences in the percentages of INR values within individually prescribed INR range and of critical INR values.

Results: The records of 33,683 patients were included in the analysis (13,568 in the "In-Person" sample; 20,115 in the "Virtual" sample). Patients in the Virtual sample achieved a TTR of 66.78%, compared to the In-Person sample (64.19%; absolute difference 2.59; 95% confidence interval [CI] = 2.50–2.68, $p < 0.001$). The TTR values were also statistically significantly higher in all subgroups evaluated across categories of patient age, gender, geography, and indication. Similarly favorable results were achieved for INR values in range and critical values.

Conclusion: Virtual education for PST for warfarin therapy is effective and should continue to be an option for patients and providers throughout the pandemic, and possibly beyond.

The COVID-19 pandemic has led to rapid expansion of virtual care modalities across health care systems worldwide, presenting challenges and opportunities in maintaining high quality of care across diverse patient populations.[1,2] The ability to maintain high-quality services for outpatients prescribed warfarin during the pandemic is of particular interest due to the fact that the drug requires tight control of the international normalized ratio (INR) to minimize serious bleeding and thrombotic events.

Maintaining the INR within therapeutic range is key to maximizing warfarin's effectiveness at preventing thrombotic events while minimizing bleeding risk, and INR control is best maintained through well-designed and controlled care systems.[3,4] Patient self-testing (PST) at home is one widely used warfarin management model that has been shown to maintain high levels of INR control, is associated with low rates of adverse outcomes associated with bleeding or thrombosis[5,6] and is a recommended guideline by professional organizations.[7] Beyond INR control, PST has other advantages, such as improved patient quality of life as compared to traditional clinical management[8,9] and expanded access to high-quality anticoagulation management for patients residing in rural regions.[7,10] In the context of the COVID-19 pandemic, PST also minimizes in-person encounters with clinical personnel and travel associated with office visits.[11]

However, until recently, not all aspects of PST have been executed virtually. Prior to the COVID-19 pandemic in the United States, Medicare coding and coverage policies required that new patients successfully complete in-person training by a health care provider prior to initiating PST.[12] Recognizing the risk of continuing this requirement in the face of the pandemic, a federal waiver was announced in March 2020 that allowed for a temporary transition to completely virtual training for new PST patients.[13]

The change from in-person to virtual training provided an excellent opportunity to explore the impact of virtual training on INR time in therapeutic range (TTR). This analysis compares the quality of INR control of new PST patients trained virtually during the COVID-19 pandemic to that of patients receiving traditional in-person training prior to the COVID pandemic.

METHODS

This pre-post retrospective observational study compares the INR control of patients who initiated PST and received in-person PST training immediately before the COVID-19 pandemic (April 1, 2019, to December 31, 2019; "In-

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Person" sample) with those who initiated PST and received virtual training during the pandemic (April 1, 2020, to December 31, 2020; "Virtual" sample). The study met criteria for exemption from Institutional Review Board (IRB) review as determined by Advarra IRB (Columbia, Maryland).

All patients included in the analysis were enrolled in the PST program provided by Alere Home Monitoring, Inc. (dba Acelis Connected Health, "ACH"). A subsidiary of Abbott Laboratories, ACH is a Centers for Medicare & Medicaid Services (CMS)–approved Independent Diagnostic Testing Facility that receives referrals from clinicians for patients to initiate PST. ACH then performs the required patient education and provides the patients with point-of-care testing devices and necessary supplies. Through the program, patient INR values are reported back to the referring clinicians, who are responsible for all warfarin dosing and patient management decisions.

All patients in the analysis resided in the United States and were 19 years of age and older at the time of referral by their clinicians. The ACH data set includes records of patients with services reimbursed through all major insurance types. For Medicare eligibility, beneficiaries must have required chronic oral anticoagulation with warfarin for an approved indication (for example, mechanical heart valve, chronic atrial fibrillation, venous thromboembolism), taken warfarin with regular outpatient (non-PST) monitoring for at least three months prior to use of the home INR device, and been instructed by their physicians to conduct home testing with the device no more frequently than once a week.[12] These eligibility requirements were similar for patients with other insurance coverage types and were not affected by the COVID-19 pandemic. In the process of evaluating referrals, ACH documents a number of standard patient characteristics, including date of birth, gender, and primary diagnosis for warfarin (as ICD-10). For patients proceeding through training to perform PST, ACH also documents the date, time, and value of every individual INR test reported through the program.

In-Person Sample

For the current retrospective analysis, the In-Person sample (that is, pre-COVID-19) was limited to patients referred for and receiving PST services between April 1, 2019, and December 31, 2019, who recorded their first PST INR value in that interval and who completed two or more INR tests in the measurement period. Patients with gaps between INR tests of greater than 60 days in the measurement period were excluded from analysis.

In-person patients referred to the Acelis Connected Health (ACH) Face-2-Face® training program in this interval had an INR monitor (Roche CoaguChek® XS or Roche CoaguChek Vantus) shipped (via FedEx, 2-day air) to their homes. ACH–approved trainers receiving the assigned case engaged patients by phone within 48 hours to schedule an in-home training appointment to be completed within 10 days from the date of referral.

Trainers were instructed to spend at least 60 minutes with the patient addressing key points according to a comprehensive training and documentation manual. Sessions included live demonstrations facilitated by the trainer with a noncalibrated "demo" meter, as well as multiple live INR tests performed by the patient on their assigned meter. Testing was considered successful if the patient achieved the following:

- Demonstrated no physical or cognitive barriers precluding successful testing and reporting of results
- Demonstrated the ability to perform two or more INR tests and report them via the patient's preferred method (HealthCheck app for tablets and smart phones, ACHHealthCheck.com for computers, Interactive Phone Recognition for telephones)
- Completed all items in the Key Points and Knowledge Assessment (Table 1)

Virtual Sample

The Virtual sample was limited to patients referred for and receiving PST services between April 1, 2020, and December 31, 2020, who recorded their first PST INR value in that interval and who completed two or more INR tests in the measurement period. Patients with gaps between INR tests of greater than 60 days in the measurement period were likewise excluded from analysis.

Despite the pandemic, the underlying eligibility requirements for PST under the Medicare program did not change (that is, number of prior months using warfarin). However, given the restrictions put in place by national and state health authorities, and in alignment with applicable emergency orders and waivers for health services, the training process for patients referred to the program in this interval was converted from in-person to virtual encounters.[13]

All of the necessary supplies were shipped to patients in their homes, and all required training and assessment activities (Table 1) were performed remotely by ACH personnel according to a modified training manual using the Webex® videoconferencing platform (Cisco Systems, Inc., San Jose, California). Virtual training was interactive and performed in real time using bidirectional video and voice features of the platform. As with the in-person training, trainers were to spend at least 60 minutes per session. The modified training manual included additional resources for trainers regarding the following:

- Establishing and maintaining an adequate Webex connection
- Ensuring patient receipt of all necessary resources
- Leading an engaging and effective virtual training session
- Assessing patient physical and cognitive aptitude for PST

Table 1. Key Points and Knowledge Assessment for INR Patient Self-Testing Training

Equipment, Supplies, and Preparation
• Received meter, test strips, code chip
• Received lancet device and disposable lancets
• Demonstrated insertion and removal of batteries
• Set up date, time, and result format
• Inserted new chip properly
• Prepared lancet device with new lancet properly
• Washed hands and demonstrated proper hand preparation for finger stick
Testing Procedure
• Inserted test strip properly
• Performed code matching properly
• Waited for meter to warm up sufficiently
• Timed use of lancet properly for use with meter
• Utilized lancet effectively and applied adequate blood drop to meter correctly
• Disposed of contaminated supplies properly
Reading and Reporting Results
• Effectively read and recorded every attempt performed during training
• Contacted physician if INR < 1.5, > 5.0, or repeated errors indicative of extremely elevated INR
• Demonstrated ability to retrieve stored results from memory
• Comprehended prescribed reporting instructions and reported results accordingly
Problem Solving
• Demonstrated understanding of use of Error Message section of user manual
• Demonstrated understanding of how and when to contact ACH for assistance
Cleaning
• Demonstrated understanding of cleaning frequency and maintenance procedure
Knowledge Assessment
• Correctly answered all questions in True/False knowledge assessment
Acknowledgments and Authorizations
• Executes all acknowledgments and assessments relating to receipt of necessary resources, physician-prescribed monitoring plan, sharing of medical information and billing for services
• *Both the trainer and the patient must attest to completion of all of the above steps for training to be considered successful.*

INR, international normalized ratio; ACH, Acelis Connected Health.

- Evaluating successful completion of all Key Points and Knowledge Assessment items
- Troubleshooting and problem solving during virtual training encounters

Outcome Testing

The primary outcome was the difference in warfarin TTR (Rosendaal method[14]) between the Virtual and In-Person samples, with secondary outcomes including differences in the percentages of INR values within individually prescribed INR range (PINRR) and of critical INR values (that is, INR < 1.5 or > 5.0). The z-test for proportions for two independent dichotomous samples was performed for each measure, with a p value of < 0.05 being considered statistically significant.[15] Two-sided 95% confidence intervals (CIs) were also constructed for each outcome measure. Baseline patient characteristics for the measurement intervals were compared using the t-test for continuous variables and the chi-square test for categorical variables. Statistical calculations were performed with R, version 3.6.0 (R Foundation for Statistical Computing, Vienna), and TTR calculations were performed using Microsoft SQL 13.0 (Microsoft Corp., Redmond, Washington).

Univariate analysis was also performed for subgroups based on age bands, gender, and primary indication for anticoagulation (by ICD-10). In addition, subanalysis was performed based on patient geography. Patient zip code was used to assign 1 of 10 US Department of Agriculture (USDA) rural-urban commuting area (RUCA) codes to each patient.[16] The codes were then aggregated into three categories: metropolitan (RUCA codes 1–3), micropolitan (codes 4–6), and small town/rural (codes 7–10).

RESULTS

Upon application of inclusion and exclusion criteria, the records of 33,683 patients were included in the final analysis (13,568 In-Person sample; 20,115 Virtual sample), with the number of patients included in the Virtual sample representing a 25.5% increase over the average for the four prior years of service (2016, 2017, 2018, 2019) interval. Approximately 0.4% of patient addresses failed to match to an RUCA region, and associated records were excluded from subanalyses relating to geography. Overall, the patients were of mean age of 70.8 years with nearly equal proportions of males and females included (Table 2). The predominant indications for warfarin therapy were atrial fibrillation (54.80%) and cardiac implants; that is, valves (15.99%). Small but statistically significant differences were seen in patient age, days of therapy, number of completed tests, and referral diagnosis. Similar proportions of patients

Table 2. Patient Demographics

	2019 ($n = 13{,}568$)	2020 ($n = 20{,}115$)
Age, mean years (SD)	70.38 (14.06)	71.06 (13.86)*
Male, % (SD)	52.55 (0.43)	52.19 (0.35)
Days of therapy in interval, mean per patient (SD)	126.87 (76.07)	139.52 (76.71)*
INR tests completed in interval, mean per patient (SD)	11.82 (8.68)	12.27 (8.5)*
Indication for PST (ICD-10)†		
Atrial fibrillation and flutter, n (%)	7,507 (55.33)	10,951 (54.44)
Presence of cardiac and vascular implants, *n* (%)	2,235 (16.47)	3,151 (15.66)
Long-term current drug therapy, *n* (%)	1,065 (7.85)	1,540 (7.66)
Personal history of certain other diseases, *n* (%)	769 (5.67)	1,770 (8.80)
Pulmonary embolism, *n* (%)	704 (5.19)	1,157 (5.75)
Other venous embolism and thrombosis, n (%)	634 (4.67)	429 (2.13)
Other coagulation defects, *n* (%)	437 (3.22)	759 (3.77)
Cerebral infarction, *n* (%)	32 (0.24)	45 (0.22)
Other pulmonary heart diseases, *n* (%)	29 (0.21)	57 (0.28)
Myocardial infarction, *n* (%)	26 (0.19)	42 (0.21)
Other ICD-10, *n* (%)	130 (0.96)	214 (1.06)
Geography		
Metropolitan, *n* (%)	11,299 (83.28)	16,786 (83.45)
Micropolitan, *n* (%)	1,215 (8.95)	1,776 (8.83)
Small town/rural, *n* (%)	1,052 (7.75)	1,418 (7.05)
Unknown, *n* (%)	2 (0.01)	135 (0.67)

* $p < 0.01$.
† $p < 0.01$ for comparison across all ICD-10 categories.SD, standard deviation; INR, international normalized ratio; PST, patient self-testing program.

were excluded from analysis due to greater than 60 days gaps between INR readings in the In-Person (7.92%) and Virtual (8.19%) samples.

Primary Measure

In the In-Person sample there were 1,721,423 evaluable care days, among which 1,104,896 were imputed to be within prescribed therapeutic range by the Rosendaal method (TTR 64.19%) (Table 3). In the Virtual sample there were 2,806,340 evaluable care days, among which 1,873,946 were imputed to be in range (TTR 66.78%), which was statistically significantly greater than that of the In-Person sample (absolute difference 2.59; CI = 2.50–2.68, $p < 0.001$). The TTR values were also statistically significantly higher in all subgroups evaluated across categories of patient age, gender, geography, and indication.

Secondary Measures

Percentage of INRs in Range. In the In-Person sample there were 160,387 evaluable INR readings, among which 97,046 were found to be within the prescribed INR range (60.51%). In the Virtual sample there were 246,711 evaluable INR readings, among which 154,448 were found to be within the prescribed INR range (62.60%) (Table 4), which was statistically significantly greater than that of the In-Person sample (absolute difference 2.09; CI = 1.78–2.40, $p < 0.001$). The PINRR values were also significantly higher in all subgroups evaluated across categories of patient age, gender, geography, and indication except for the subcategories of "Cerebral Infarction" and "Other ICD-10."

Critical INR Values. In the In-Person sample there were 160,387 evaluable INR readings, among which 8,066 were found to be critical values (5.03%). In the Virtual sample there were 246,711 evaluable INR readings, among which 10,068 were found to be critical values (4.08%) (Table 5), which was significantly fewer than observed in the In-Person sample (absolute difference -0.95; CI = -1.08– -0.81, $p < 0.001$). The proportion of critical values was also numerically lower in all Virtual sample subgroups evaluated across categories of patient age, gender, geography, and indication, with the differences achieving statistical significance in all subgroups except for "Micropolitan," "Pulmonary Embolism," "Cerebral Infarction," "Other Pulmonary Heart Diseases," and "Other ICD-10." The proportions of low vs. high critical values were similar in the In-Person and Virtual cohorts, with the majority in both groups (72.05% in the In-Person cohort and 71.29% in the Virtual cohort) being low.

DISCUSSION

The COVID-19 pandemic has dramatically affected the provision of health care services in the United States and globally, as evidenced by emergency authorizations and evolving guidance issued by US federal agencies.[17–19] Although temporary federal authorizations allowed for rapid expansion of telemedicine services,[18] it is important to critically evaluate the quality and safety of health care services provided via these new modalities. Careful appraisals are essential to driving continuous quality improvements for care

Table 3. Time in Therapeutic Range

	Year 2019 (n=13,568)			Year 2020 (n=20,115)			p value (CI)
	Days	In Range	TTR	Days	In Range	TTR	
All Patients	1,721,423	1,104,896	64.19	2,806,340	1,873,946	66.78	<0.001 (2.50, 2.68)
Age Range							
Age 20 - 59	342,041	211,214	61.75	487,150	311,103	63.86	<0.001 (1.89, 2.32)
Age 60 - 69	400,510	257,489	64.29	631,956	421,265	66.66	<0.001 (2.18, 2.55)
Age 70 - 79	517,049	338,551	65.48	904,465	613,482	67.83	<0.001 (2.18, 2.51)
Age 80 - 89	367,116	236,761	64.49	611,145	411,542	67.34	<0.001 (2.65, 3.04)
Age 90+	93,696	60,227	64.28	170,998	116,210	67.96	<0.001 (3.30, 4.05)
Gender							
Female	817,459	509,940	62.38	1,340,374	876,863	65.42	<0.001 (2.90, 3.17)
Male	903,964	594,956	65.82	1,465,966	997,083	68.02	<0.001 (2.07, 2.32)
Geography							
Metropolitan	1,433,739	918,725	64.08	2,350,583	1,569,482	66.77	<0.001 (2.59, 2.78)
Micropolitan	150,520	98,233	65.26	242,382	162,194	66.92	<0.001 (1.34, 1.95)
Small town/rural	136,941	87,786	64.10	196,845	131,793	66.95	<0.001 (2.51, 3.17)
RUCA Unknown	224	153	68.30	16,727	10,593	63.33	0.1428 (-11., 1.16)
Primary Indication for PST							
Atrial fibrillation and flutter	954,889	624,048	65.35	1,529,603	1,038,525	67.90	<0.001 (2.42, 2.66)
Presence of cardiac and vascular implants and grafts	288,660	176,615	61.18	443,723	278,257	62.71	<0.001 (1.29, 1.75)
Long term current drug therapy	133,085	84,614	63.58	224,799	149,828	66.65	<0.001 (2.74, 3.39)
Personal history of certain other diseases	96,794	61,699	63.74	239,039	160,644	67.20	<0.001 (3.10, 3.81)
Pulmonary embolism	83,528	53,568	64.13	159,403	106,572	66.86	<0.001 (2.32, 3.12)
Other venous embolism and thrombosis	78,886	50,261	63.71	56,591	38,292	67.66	<0.001 (3.44, 4.46)
Other coagulation defects	58,175	37,020	63.64	104,791	69,075	65.92	<0.001 (1.79, 2.76)
Cerebral infarction	3,993	2,561	64.14	5,865	3,961	67.54	<0.001 (1.48, 5.30)
Other pulmonary heart diseases	3,232	1,904	58.91	8,141	5,668	69.62	<0.001 (8.74, 12.6)
Myocardial infarction	3,310	1,896	57.28	6,299	4,457	70.76	<0.001 (11.4, 15.5)
Other. ICD-10	16,871	10,710	63.48	28,086	18,667	66.46	<0.001 (2.06, 3.89)

Days, total evaluable patient care days in measurement interval; In Range, number of days imputed to be within prescribed therapeutic range; TTR, time in therapeutic range per Rosendaal method (see reference 14); CI, confidence interval of difference between proportions.

processes as the pandemic persists, and will also inform the maintenance of safe, effective, and efficient care services after the pandemic.

The evaluation of systems supporting warfarin patient management during the pandemic is particularly important, as maintenance of the INR within a narrow therapeutic range is critical to avoid life-threatening thromboembolic and hemorrhagic events. The current analysis describes the quality of INR control among a sample of more than 20,000 patients from across the United States initiating PST during nine peak months of the COVID-19 pandemic. Compared to patients initiating PST in the same calendar months from the year prior, the level of INR control was not only equivalent, but overall was statistically significantly superior across the domains of TTR,[14] PINRR, and critical values. Further, a comparable level of INR control was maintained across every subgroup evaluated, with numerical and statistical superiority being achieved among the Virtual sample in the majority of subanalyses.

Our study noted an overall increase in patients referred for PST during the COVID-19 pandemic compared with the preceding years, consistent with the broader pandemic-associated expansion of virtual health care modalities. This increase in enrollment was consistent across available demographics (age and gender), indication for anticoagulation, and type of location (metropolitan, micropolitan, or small town/rural). This analysis demonstrates that the transition from face-to-face to virtual patient training did not negatively affect patients' ability to master PST and achieve treatment goals (that is, maintain INR within prescribed therapeutic range) regardless of age, gender, indication, or geographic setting.

The value of converting components of warfarin management to virtual options is substantiated by evaluations of processes implemented in the COVID era in other countries. A tertiary care teaching hospital in India achieved a statistically significantly higher level of INR control among patients using their new virtual management program as compared to those remaining in traditional in-office management (TTR 75.4% vs. 71.2%, $p < 0.001$; PINRR 66.7% vs. 62.4%, $p < 0.001$).[20] Another tertiary care center in India implementing a remote management program ($N = 1{,}214$) in response to the pandemic demonstrated no significant differences in rates of patients experiencing supratherapeutic or subtherapeutic INRs during the measurement interval.[21] In addition, they identified no signifi-

Table 4. INR Readings Within Prescribed Range

	Year 2019 (n=13,568)			Year 2020 (n=20,115)			p value (CI)
	Readings	In Range	Percent	Readings	In Range	Percent	
All Patients	160,387	97,046	60.51	246,711	154,448	62.60	<0.001 (1.78, 2.40)
Age Range							
Age 20 - 59	33,175	19,241	58.00	44,840	26,850	59.88	<0.001 (1.18, 2.57)
Age 60 - 69	37,022	22,348	60.36	56,173	35,055	62.41	<0.001 (1.40, 2.68)
Age 70 - 79	47,931	29,721	62.01	78,362	49,841	63.60	<0.001 (1.04, 2.14)
Age 80 - 89	33,601	20,533	61.11	52,483	33,174	63.21	<0.001 (1.43, 2.76)
Age 90+	8,548	5,138	60.11	14,800	9,500	64.19	<0.001 (2.78, 5.37)
Gender							
Female	77,069	45,223	58.68	120,080	73,402	61.13	<0.001 (2.00, 2.89)
Male	83,318	51,823	62.20	126,631	81,046	64.00	<0.001 (1.38, 2.22)
Geography							
Metropolitan	132,883	80,176	60.34	204,849	128,056	62.51	<0.001 (1.84, 2.51)
Micropolitan	14,227	8,810	61.92	21,812	13,778	63.17	0.0176 (0.21, 2.26)
Small town/rural	13,260	8,048	60.69	18,545	11,713	63.16	<0.001 (1.38, 3.54)
RUCA Unknown	17	12	70.59	1,522	911	59.86	0.516 (-32., 11.0)
Primary Indication for PST							
Atrial fibrillation and flutter	86,515	53,665	62.03	131,208	83,894	63.94	<0.001 (1.49, 2.32)
Presence of cardiac and vascular implants and grafts	28,503	16,150	56.66	41,730	24,305	58.24	<0.001 (0.83, 2.32)
Long term current drug therapy	13,361	8,007	59.93	20,143	12,682	62.96	<0.001 (1.96, 4.09)
Personal history of certain other diseases	8,699	5,198	59.75	20,817	13,077	62.82	<0.001 (1.84, 4.28)
Pulmonary embolism	7,805	4,760	60.99	14,070	8,787	62.45	0.0336 (0.11, 2.81)
Other venous embolism and thrombosis	7,401	4,447	60.09	5,064	3,176	62.72	0.0031 (0.89, 4.36)
Other coagulation defects	5,544	3,298	59.49	9,338	5,780	61.90	0.0037 (0.78, 4.03)
Cerebral infarction	362	219	60.50	594	384	64.65	0.2223 (-2.1, 10.4)
Other pulmonary heart diseases	327	168	51.38	753	498	66.14	<0.001 (8.37, 21.1)
Myocardial infarction	307	166	54.07	545	358	65.69	0.0010 (4.76, 18.4)
Other ICD-10	1,563	968	61.93	2,449	1,507	61.54	0.8268 (-3.4, 2.68)

INR, international normalized ratio; Readings, total number of INR tests performed; In Range, total number of INR test results within individual patients' prescribed target range; CI, confidence interval of difference between proportions.

cant differences in rates of hospitalization, bleeding events, or thromboembolic episodes. Similarly, a regional outpatient hematology center in Brazil converted warfarin patients to telephonic management and retained comparable levels of INR control (TTR 63% vs. 62%, $p = 0.78$).[22]

To our knowledge, this study is the largest evaluation of COVID–era TTR quality available and the only study of its kind in the United States to date. The current analysis has a number of strengths, including the size and diversity of the evaluated patient samples, the standardization of training materials, the uniformity in INR testing technology and results reporting, and, most importantly, the standardized measure of INR time in range as a validated quality indicator.

However, the analysis also has limitations. As ACH is entirely dependent on clinician referrals for PST services, it is possible that the In-Person and Virtual patient populations differ in ways that cannot be measured with available data. Likewise, the levels of warfarin management expertise of referring clinicians and their decision-making processes relating to PST referrals and warfarin management before and during the pandemic were impossible to assess.

Although the analysis showed an overall increase in number of patients referred for PST across the categories of patient characteristics studied, the data set does not include information on socioeconomic status, education level, or other characteristics that might have affected patients' access to or engagement with virtual training modalities. With the In-Person and Virtual cohorts, patients were referred only after an initial three-month period of stability on warfarin. This analysis therefore does not include patients who were not stable for that initial period—potentially a particularly vulnerable population. However, we would not expect significant differences in these two groups with regard to this characteristic.

The data set also lacks information on comorbid illnesses and medication use beyond warfarin that may affect INR control (for example, renal function, antibiotic use) and does not include information on adverse clinical outcomes, such as actual bleeding and thrombotic events. As such, inferences regarding actual patient outcomes between the In-Person and Virtual intervals cannot be drawn directly from the available data. However, other studies have demonstrated an association between high TTR and improved clinical outcomes among patients with atrial fibrillation,[23] prosthetic heart valves,[24] and venous thromboembolism,[25] making the high level of TTR control achieved during the COVID-19 pandemic clinically relevant.

Table 5. Critical INR Values

	Year 2019 (n=13,568)			Year 2020 (n=20,115)			p value (CI)
	Readings	Critical	Percent	Readings	Critical	Percent	
All Patients	160,387	8,066	5.03	246,711	10,068	4.08	<0.001 (-1.08, -0.81)
Age Range							
Age 20 - 59	33,175	1,902	5.73	44,840	2,230	4.97	<0.001 (-1.08, -0.43)
Age 60 - 69	37,022	1,987	5.37	56,173	2,285	4.07	<0.001 (-1.58, -1.01)
Age 70 - 79	47,931	2,165	4.52	78,362	3,052	3.89	<0.001 (-0.85, -0.39)
Age 80 - 89	33,601	1,577	4.69	52,483	1,982	3.78	<0.001 (-1.19, -0.63)
Age 90+	8,548	429	5.02	14,800	516	3.49	<0.001 (-2.08, -0.98)
Gender							
Female	77,069	4,225	5.48	120,080	5,360	4.46	<0.001 (-1.21, -0.81)
Male	83,318	3,841	4.61	126,631	4,708	3.72	<0.001 (-1.06, -0.71)
Geography							
Metropolitan	132,883	6,757	5.08	204,849	8,350	4.08	<0.001 (-1.15, -0.86)
Micropolitan	14,227	649	4.56	21,812	936	4.29	0.2309 (-0.70, 0.165)
Small town/rural	13,260	659	4.97	18,545	697	3.76	<0.001 (-1.67, -0.75)
Unknown	17	1	5.88	1,522	85	5.58	1.000 (-11.5, 10.94)
Primary Indication for PST							
Atrial fibrillation and flutter	86,515	4,104	4.74	131,208	5,022	3.83	<0.001 (-1.09, -0.74)
Presence of cardiac and vascular implants and grafts	28,503	1,468	5.15	41,730	1,766	4.23	<0.001 (-1.23, -0.59)
Long term current drug therapy	13,361	701	5.25	20,143	860	4.27	<0.001 (-1.44, -0.50)
Personal history of certain other diseases	8,699	527	6.06	20,817	954	4.58	<0.001 (-2.05, -0.89)
Pulmonary embolism	7,805	367	4.70	14,070	613	4.36	0.2507 (-0.92, 0.232)
Other venous embolism and thrombosis	7,401	452	6.11	5,064	264	5.21	0.0386 (-1.71, -0.07)
Other coagulation defects	5,544	289	5.21	9,338	397	4.25	0.0077 (-1.67, -0.24)
Cerebral infarction	362	10	2.76	594	12	2.02	0.603 (-2.77, 1.290)
Other pulmonary heart diseases	327	17	5.20	753	21	2.79	0.0726 (-5.08, 0.268)
Myocardial infarction	307	32	10.42	545	27	4.95	0.0039 (-9.34, -1.59)
Other ICD-10	1,563	99	6.33	2,449	132	5.39	0.2371 (-2.44, 0.558)

INR, international normalized ratio; Readings, total number of INR tests performed; Critical, total number of INR test results < 1.5 or > 5.0; CI, confidence interval of difference between proportions.

Finally, the data set does not contain variables that can account for clinical and social factors related to the COVID-19 pandemic that may have influenced the quality of INR control. It is possible that pandemic-related factors such as telecommuting, unemployment, reduced access to restaurants, limitations on travel, and other pandemic-related factors may have affected warfarin adherence and INR control, but the impact of such factors cannot be evaluated with available data to the ACH PST program. Although the conversion from in-person to virtual training was the only control variable evaluated in the available data set, the improvements seen in TTR, PINRR, and critical values may not be clearly attributable to that transition. Additional research into other pandemic-related factors that affect patient medication adherence and INR control is warranted.

CONCLUSION

Patients receiving virtual training for warfarin PST during the COVID-19 pandemic achieved equivalent or superior levels of INR control than patients initiating PST with in-person training immediately preceding the pandemic. PST with virtual training should continue to be an option available to well-suited patients requiring warfarin therapy. Virtual training for warfarin PST may help improve access to care for patients with geographic or scheduling limitations and may serve as a model for other educational interventions to support patient care.

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