Targeting patient and health system barriers to improve rates of hemodialysis initiation with an arteriovenous access

Jennifer E. Flythe¹,², Julia H. Narendra¹, Christina Yule³, Surya Manivannan¹, Shannon Murphy¹, Shoou-Yih D. Lee⁴, Tara S. Strigo⁵, Sarah Peskoe⁶, Jane F. Pendergast⁶, L. Ebony Boulware⁵, and Jamie A. Green³,⁷

1. University of North Carolina (UNC) Kidney Center, Division of Nephrology and Hypertension, Department of Medicine, UNC School of Medicine, Chapel Hill, NC
2. Cecil G. Sheps Center for Health Services Research, University of North Carolina, Chapel Hill, NC
3. Kidney Health Research Institute, Geisinger, Danville, PA
4. Department of Health Administration, College of Health Professions, Virginia Commonwealth University, Richmond, VA
5. Division of General Internal Medicine, Duke University School of Medicine, Durham, NC
6. Department of Biostatistics and Bioinformatics, Duke University School of Medicine, Durham, NC
7. Department of Nephrology, Geisinger Commonwealth School of Medicine, Danville, PA

Corresponding Author: Jennifer E. Flythe MD, MPH
University of North Carolina Kidney Center
7024 Burnett-Womack CB #7155
Chapel Hill, NC 27599-7155
jflythe@med.unc.edu
(tel) 919-445-2656
(fax) 919-966-4251
KEY POINTS

- Targeting barriers to AV access through education, needs assessment, peer support, care navigation, and electronic supports was acceptable.
- The program yielded improvements in patient self-efficacy and knowledge and trends toward improvements in patient and provider confidence.

ABSTRACT

Background: Guidelines recommend preemptive creation of arteriovenous (AV) access. However, fewer than 20% of U.S. patients initiate hemodialysis (HD) with a functional AV access. We implemented a quality improvement (QI) program to improve pre-HD vascular access care.

Methods: After conducting qualitative research with key informants, we implemented a 7-month vascular access support QI program at Geisinger Health. The program targeted patient and health system barriers to AV access through education, needs assessment, peer support, care navigation, and electronic supports. We performed pre-, intra, and post-program stakeholder interviews to identify program barriers and facilitators and assess acceptability. In a research sub-study, we compared pre- and post-program self-efficacy, knowledge, and confidence navigating vascular access care.

Results: There were 37 patient and 32 clinician/personnel participants. Of the 37 patients, 34 (92%) completed vascular access-specific education, 33 (89%) underwent needs assessment, 8 (22%) engaged with peer mentors, 21 (57%) had vein mapping, 18 (49%) had an initial surgical appointment, 15 (40%) underwent AV access surgery, and 6 (16%) started HD during the 7-month program. Qualitative findings demonstrated program acceptability to participants and suggested that education provision and emotional barrier identification were important to
engaging patients in vascular access care. Research findings showed pre- to post-program improvements in patient self-efficacy (28.1 to 30.8, $p=0.05$) and knowledge (4.9 to 6.9, $p=0.004$) and trends toward improvements in confidence among patients (8.0 to 8.7, $p=0.2$) and providers (7.5 to 7.8, $p=0.1$).

**Conclusions:** Our intervention targeting patient and health system barriers improved patient vascular access knowledge and self-efficacy.
INTRODUCTION

Vascular access is one of the most challenging and expensive aspects of hemodialysis (HD) care. Use of an arteriovenous (AV) access (fistula or graft) is associated with lower sepsis risk, lower hospitalization rates, and 50% lower mortality rates as compared to use of a catheter.1-6 Experts have estimated that a 50% increase in AV access-based HD initiation would lead to an annual savings of $1 billion.7 However, <20% of individuals in the U.S. start maintenance HD with a functional AV access.8

Many prior efforts to increase AV access use focused on access creation after HD initiation. Encouragingly, the Fistula First Initiative9 led to a 30% increase in fistula use among prevalent HD patients by targeting healthcare organizational deficiencies and inadequate patient education.10 However, there has been markedly less success in the pre-dialysis period. Health system barriers (e.g., complex care processes, insufficient inter-provider communication)11-13 and patient barriers (e.g., fear, inadequate education)14, 15 likely contribute to low rates of AV access-based HD initiation. Prior research suggests that assistance with care navigation improves aspects of vascular access care, but care navigation alone has not been shown to improve AV access-based HD initiation in the U.S.16, 17 Such findings suggest that barriers exist beyond those related to care processes. Prior interventions have not sufficiently addressed patient-level barriers such as fear, dialysis reluctance, and worries about body disfigurement and needles which also impede care.14-16, 18-23

We conducted a quality improvement (QI) project targeting both patient and health system barriers to AV access-based HD initiation with the goal of improving pre-HD vascular access care outcomes and patient experiences. Simultaneously, we conducted a research sub-study to assess the intervention’s effect on patient- and care team-reported outcomes.
METHODS

Overview

Figure 1 depicts project activities. To inform intervention development, we conducted qualitative research to elicit perceived barriers to pre-HD AV access creation from key stakeholders. We then developed our intervention and implemented it as a QI project at Geisinger Health. During implementation, we collected data on participant experiences and clinical processes, responsively updating the intervention to optimize its implementation. In addition, we offered QI participants the opportunity to enroll in a research sub-study examining changes in patient self-efficacy, knowledge, and confidence and medical provider/personnel confidence.

This was an ancillary project to the PREPARE NOW study, a cluster-randomized controlled trial designed to quantify the effectiveness of integrated health system interventions to improve patients’ preparation for kidney failure treatments. The QI project was approved by Geisinger Health, and all protocols were approved by the Duke Health Institutional Review Board (IRB), the Central IRB for PREPARE NOW (IRB Pro00075488). All participants provided consent to access their electronic health records (EHRs). We performed, analyzed, and reported the QI project in accordance with Standards for Quality Improvement Reporting Excellent Guidelines (Supplemental Table S1). We conducted our intervention as QI to support a systematic, clinic-level approach to implementation and evaluation. We assessed knowledge, self-efficacy, and confidence in a research subset so as not to burden all QI participants with additional questionnaires. Research sub-study participants provided additional consent. We registered the research sub-study on Clinicaltrials.gov (NCT04032613).

Quality improvement intervention: vascular access support program

We designed the vascular access support program to support patients through preemptive AV access creation by targeting patient and health system barriers. The program consisted of 1) vascular access-specific patient education, 2) needs and barriers assessments,
3) peer mentoring, 4) care navigation, and 5) a vascular access-specific electronic dashboard for navigators (Table 1). Nurse navigators used a previously described CKD EHR registry\textsuperscript{24} to identify patients potentially eligible for the program and, after obtaining agreement from the treating nephrologist, enrolled patients. Upon program enrollment, patients were scheduled for an education session and a needs and barriers assessment. During the education session, patients were offered the opportunity to connect with a peer mentor. The navigators then supported each patient through AV access processes by issuing appointment reminders, assisting with scheduling, and providing resources. Throughout, they used a vascular access-specific electronic dashboard to monitor progress.

**Setting and participants**

Geisinger Health provides care for over 4 million people in 45 Pennsylvania counties and 7 southern New Jersey counties. The QI intervention was implemented at the Geisinger Danville Nephrology Clinic, a sub-specialty clinic with 10 nephrologists who care for ~1,500 individuals with kidney disease. We selected this clinic because it was not randomized in the PREPARE NOW study.

Danville Nephrology Clinic patients who had an estimated glomerular filtration rate (eGFR) \( \leq 25 \) mL/min/1.73m\(^2\) and a 2-year kidney failure risk equation (KFRE)\textsuperscript{26, 27} of >10\% were eligible to participate in the QI program with agreement from their nephrologist. Patients were excluded if they were planning for peritoneal dialysis (PD) or conservative care, had already initiated the AV access creation process, or had cognitive impairment. Navigators identified potentially eligible patients from the CKD registry\textsuperscript{24} and assessed eligibility via chart review. All patients participating in the QI program were eligible for the research sub-study. Medical providers and personnel at the participating clinic and associated surgery and radiology clinics were also research-eligible.

To inform QI program development, we performed focus groups and interviews with patients, caregivers, and providers/personnel. Focus groups and interviews were held at
Geisinger Health, a semi-closed system integrated with a single insurer serving a rural population, and University of North Carolina (UNC) Health System, an open, network-based system serving a socioeconomically and racially diverse mid-sized metropolitan population. Patients with non-dialysis-dependent advanced CKD (eGFR ≤20 mL/min/1.73m²) with a preference for HD (and caregivers) and patients with dialysis-dependent kidney failure who have initiated HD within 1 year (and caregivers) were eligible to participate in focus groups. Interview participants included nephrologists, surgeons, and interventionalists, as well as nephrology, surgery, and radiology clinic nurses, managers, and schedulers. We used purposive sampling to recruit individuals with differing vascular access and professional experiences.

Data collection

Focus groups and interviews

Trained research assistants conducted the pre-intervention focus groups and semi-structured interviews using standardized moderator and interview guides (Supplemental Table S2). Focus groups were 60-90 minutes, and interviews were 30-45 minutes. Both were recorded and professionally transcribed. Participants provided informed consent.

After drafting the intervention protocol, we conducted pre-implementation interviews with clinic stakeholders to assess resource availability, program perceptions, and intervention fit. We then conducted intra-implementation interviews with participating patients and care team members to assess program barriers, facilitators, and acceptability. We captured participants’ perceptions of program impact and potential for sustainability with post-implementation interviews. Trained interviewers used interview guides and structured note templates to conduct and document all interviews. Interviews were conducted under QI protocols.

Electronic health record

During the QI program, we collected relevant EHR data, including demographics, comorbidities, laboratory results, inpatient and outpatient encounters and procedures, and
vascular access type at HD initiation, on all enrolled patients. Pre-specified exploratory QI program clinical outcomes included number of completed vascular access care steps, number and type of patient-level barriers to vascular access care, number and type of peer mentoring contacts, and vascular access type at HD initiation.

**Patient and care team-reported outcomes**

Research sub-study participants completed pre- and post-program questionnaires (Supplemental Table S3). Patients completed the 8-item Perceived Kidney Disease Self-Management Scale\textsuperscript{28} and investigator-developed questionnaires on vascular access knowledge (8 items) and confidence in navigating vascular access care (3 items). Care team members completed an 11-item investigator-developed questionnaire assessing confidence in helping patients navigate vascular access care.

**Analysis**

**Qualitative data**

We analyzed pre-program qualitative data to identify barriers to AV access-based HD initiation. We imported transcriptions into ATLAS.ti software (Version 7, Berlin, Germany) and analyzed the data using directed content analysis.\textsuperscript{29, 30} Three team members (S.M., S.L.M., J.H.N) used line-by-line coding to group text according to pre-specified barrier types (patient, health system), adding new codes when text could not be categorized within the initial coding scheme. Through triangulation, researchers (S.M., S.L.M., J.H.N, J.E.F.) resolved discrepancies and developed a final coding framework. Findings were used to inform QI program development.

We analyzed data from pre-, intra-, and post-intervention interviews to characterize program perceptions and identify opportunities for refinement. Data were compiled into tables organized by interview timing, interviewee type, and program component. When considering refinements to the QI program based on implementation challenges identified during stakeholder interviews, we weighted information provided by two or more interviewees.
**Quantitative data**

We used descriptive statistics (e.g., count (%), median [interquartile range]) to report program participant characteristics and program component completion. We compared pre- and post-program questionnaire scores using paired student’s t-tests. Analyses were performed in SAS v9.4 and R v3.3.2 or later.

**RESULTS**

**Pre-QI program findings and intervention refinement**

**Barriers to AV access-based HD initiation**

We conducted 4 focus groups with 18 patients and 6 caregivers, and 16 individual interviews with providers/personnel (Supplemental Table S4). Table 2 displays the identified barriers to AV access-based HD initiation.

Participants identified the patient barriers of negative emotions (fear, uncertainty, denial) and inadequate education, and the health system barriers of poor inter-provider communication and lack of a centralized approach to care navigation as important obstacles to pre-HD vascular access care. Specifically, patients reported that feelings of fear and uncertainty about starting dialysis often led to denial and, subsequently, inertia and poor engagement in their care. Low engagement was compounded by inadequate education about vascular access, leaving many to arrive at appointments ill-equipped to engage in shared decision-making and unprepared for potential complications and/or extra procedures that often arose. Both providers and patients noted that these patient barriers were exacerbated by health system challenges such as poor inter-provider communication and lack of coordinated systems. As a result, many patients started the AV access creation process, but never finished before HD initiation. Participants of all types suggested that strong patient-provider relationships, dedicated vascular access education, peer support, care partner involvement, and individualized care navigation may help overcome these barriers.
Responsive updates to the QI intervention

We refined our intervention in response to these findings. To address the concern that existing vascular access educational materials were overwhelming and provided too late, we developed an appropriate health literacy level educational brochure and scheduled educational sessions early in AV access evaluation (Supplemental Table S5). To better incorporate emotional and educational support, we bolstered our peer mentoring program, encouraged care navigators to involve care partners, and updated our needs and barriers assessment. Finally, we updated the electronic dashboard to be sortable by care step to support providers who lacked systematic approaches to monitoring patients.

QI program and research participant characteristics

Figure 2 and Table 3 display QI program and research sub-study participants. Of the 263 patients on the CKD registry during the project period, 44 patients met program eligibility criteria. Planning for conservative care (n=45), eGFR >25 mL/min/1.73m² (n=37), and planning for PD (n=30) were the most common exclusion reasons, and 31 (12%) remained under review at program end (i.e., awaiting nephrologist approval of program enrollment). Of the 44 eligible patients, 37 (84%) and 21 (48%) patients were enrolled in the QI program and research sub-study, respectively. QI patient participant mean age was 64 ± 14 years, 12 (32%) were female, and 36 (97%) were white. At program entry, the mean eGFR was 18 ± 5 mL/min/1.73 m², and the mean 2-year KFRE score was 43 ± 29%. Patient research participants had similar characteristics. Overall, 32 providers/personnel participated in the QI program (8 nephrologists, 14 surgeons, 6 interventionalists, 2 navigators, and 2 clinic personnel), of whom 25 participated in the research sub-study.

Clinical and patient and care team-reported outcomes

Patients were enrolled in the QI program on a rolling basis between October 1, 2019 and March 31, 2020 with 15, 2, 1, 7, 7, and 5 patients enrolled in October, November, December, January, February, and March, respectively. The mean time in the program was 4.9 ± 2.1
months. Overall, of the 37 enrolled patients, 34 (92%) completed vascular access-specific education, 33 (89%) underwent needs and barriers assessment, 8 (22%) engaged peer mentors, 21 (57%) completed vein mapping, 18 (49%) had an initial surgical appointment, 15 (40%) underwent AV access surgery, and 6 (16%) started HD during the 7-month program period. Of the 18 patients who were enrolled in the first 3 months of the program, 17 (94%) completed vascular access-specific education, 17 (94%) underwent needs and barriers assessment, 10 (56%) completed vein mapping, 10 (56%) had an initial surgical appointment, and 9 (50%) underwent AV access surgery.

The median [interquartile range] time between vein mapping and first surgical appointment, first surgical appointment and AV access surgery, and AV access surgery and HD initiation was 0 [0, 0], 26 [10, 40], and 52 [20, 56] days, respectively. Of the 6 patients who started HD, 2 had a functioning AV access, 2 had a non-mature AV access, 1 had AV access surgery within 5 days of HD initiation, and 1 had a catheter without known plans for AV access creation.

Of the 37 program participants, 10 (27%) participants expressed interest in peer mentorship, and 8 (22%) participants connected with a mentor during the program. There were a total of 30 mentor interactions (2 in-person and 28 by telephone) with a mean of 4 ± 2 encounters per dyad and a mean relationship duration of 68 ± 56 days. The most common reasons for disinterest in peer mentorship were having a friend or family member on dialysis from whom they preferred to seek information and not wanting to talk about HD until closer to initiation. Among the 33 patients who underwent needs and barriers assessment, 20 (61%), 12 (36%), 16 (48%), and 7 (21%) patients met the criteria for low education, low health literacy, financial difficulty, and limited transportation, respectively.

Research findings showed significant pre- to post-program improvements in patient self-efficacy (p=0.05) and knowledge (p=0.004) and trends toward improvements in patient (p=0.2) and provider (p=0.1) confidence (Figure 3).
QI program implementation findings and responsive changes

We conducted 14 pre-program interviews (8 patients and 6 providers/personnel), 34 intra-program interviews (29 patients and 6 providers/personnel), and 28 post-program interviews (11 patients, 4 peer mentors, and 13 providers/personnel). During the interviews, we identified a number of potential barriers to effective implementation and made responsive changes to the program and developed recommendations for future implementations (Table 4).

Program eligibility

Medical providers acknowledged the need to balance the potential challenges of too liberal of selection criteria (i.e., enrollment of patients who never start HD) and the potential harms of too restrictive criteria (i.e., missed opportunities for education, inadequate time to create functional AV access). Nephrologists found the initially proposed eGFR threshold of <20 mL/min/1.73m² too low, reporting that many patients begin vascular access planning at higher eGFRs. As such, we implemented the program using an eGFR threshold <25 mL/min/1.73m² and a 2-year KFRE >10%. However, some nephrologists were reluctant to discuss vascular access with patients with eGFRs >20 mL/min/1.73m², regardless of their KFRE scores, citing uncertainty about disease progression. A navigator noted, “The nephrologists aren’t always ready to hand off their patients.” Other nephrologists were comfortable initiating dialysis planning at eGFRs >25 mL/min/1.73m² and had already done so. In fact, some patients with eGFRs 20-30 mL/min/1.73m² had already been referred to surgery and were thus program-ineligible. This resulted in enrolling many program-eligible patients who were reluctant to start dialysis planning or were generally harder to engage in care. This is evidenced by the low mean eGFR (18 ± 5 mL/min/1.73 m²) and high mean KFRE (43 ± 29%) of program participants. In post-program interviews, navigators and nephrologists suggested that the dialysis modality education class would be an optimal time to enroll patients in the vascular access program, as class referral signified nephrologist agreement that patients were ready for kidney failure
planning. Regardless, providers considered it important to utilize EHR tools to identify patients at risk of kidney disease progression and prompt nephrologist planning.

**Program components**

**Vascular access-specific education.** Overall, participants found the education effective in preparing patients for clinical encounters, resulting in more efficient and meaningful appointments. Specifically, surgeons and interventionalists reported that patients arrived at appointments prepared to ask questions and more likely to express their concerns than they had before program implementation. To ensure delivery of consistent education, we developed guides to facilitate education sessions. Several patients suggested that a complimentary educational video with patient testimonials would strengthen future program implementations.

**Peer mentoring.** In pre-program interviews, patients emphasized the importance of learning from other patients’ experiences. In response, we bolstered the peer mentoring program by recruiting local mentors and providing them with training and vascular access education. Mentees valued the peer-to-peer interactions, describing support that could only be provided by those with lived experiences. Participants suggested adding an option for connection to a national peer program to support patients who did not find a good match in the local program.

**Needs and barriers assessment.** In response to pre-program concerns that the needs and barriers assessment overlapped with an existing Geisinger assessment, we modified the existing assessment to incorporate evaluation of vascular access-specific barriers (e.g., understanding of the vascular access-specific education). The assessments offered opportunities to not only identify patients who needed resources, but also reinforce education and answer lingering questions. Navigators viewed the education reinforcement aspect of the encounter as particularly important, with one noting, “This topic is emotional and there is a lot of information to digest. Patients have questions about how it will affect their life—it’s hard for them to digest in one sitting.”
**Care navigation and electronic supports.** Providers found the health system-focused program components integral to supporting patients. To enhance efficiency, we made the dashboard sortable by care step and added fields for text updates. To better engage nephrologists and surgeons in future program implementations, participants suggested giving medical providers access to the dashboard. Overall, the program was acceptable to medical providers/personnel; however, the navigator tasks were sometimes time-consuming.

**DISCUSSION**

Our findings demonstrate that targeting both patient and health system barriers may improve pre-dialysis vascular access care. Specifically, we showed that a multifaceted intervention designed to improve patient knowledge, address resource gaps, support emotional needs, and assist with care navigation and monitoring improves patient vascular access-related self-efficacy and knowledge and has the potential to improve clinical outcomes.

Preemptive vascular access creation requires teamwork among nephrologists, surgeons, and interventionalists. It is thus reasonable to posit that interventions facilitating care navigation and collaboration may improve AV access-based initiation rates. Yet, prior studies of such interventions have yielded mixed results. Two Australian trials showed increased rates of AV access-based HD initiation with an access coordinator\(^{20}\) and, separately, a multidisciplinary team intervention.\(^ {19}\) However, U.S. studies of similar interventions resulted in higher rates of AV access creation pre-dialysis but no significant change in *functional* AV access at HD initiation.\(^ {16, 21, 22}\) These data suggest that health systems interventions, on their own, may be insufficient to increase AV access-based HD initiation.

Qualitative studies involving more than 1,000 patients found that patients often experience emotional vulnerability, unpreparedness, and loss of control during vascular access planning.\(^ {14}\) A study of 190 CKD patients found that over 50% of participants intended to delay access creation despite early referral.\(^ {33}\) Patient perspectives from our work support these
findings and underscore the emotional weight that accompanies vascular access planning. In our intervention, we addressed patient-level barriers from several angles. For example, we incorporated vascular access-specific questions about emotional and educational needs into an existing resource assessment. In addition, we provided focused vascular access education, directly acknowledging common emotions, and explaining the care steps and potential complications (including high primary failure rates). Finally, interested patients received peer support. Post-program improvements in patient self-efficacy and vascular access knowledge suggest that these strategies were helpful in preparing patients to engage in vascular access care and may have addressed patients’ psychological and planning needs. Our qualitative findings also supported the importance of these patient-focused program components. Providers found patients to be more prepared, ultimately making encounters more meaningful and efficient. Patients also expressed appreciation for the transparent and timely communication about potential vascular access-related complications.

Our findings also highlight the importance of health system barriers, including those at the nephrologist level. Overall, the implemented eGFR and KFRE thresholds were acceptable to nephrologists, but they did identify some patients who had not yet discussed dialysis planning with their nephrologists. In some cases, navigator prompts to nephrologists led to earlier dialysis discussions, but in others, nephrologists felt planning was premature and cited concern that patients might interpret these discussions to mean that dialysis was inevitable. These practice differences are consistent with those reported elsewhere and reflect the tension nephrologists may face when balancing the benefits of preemptive access creation with the potential harm of creating unused accesses and associated complications. Expert society guidelines reveal community uncertainty about this issue. In addition, most nephrologists preferred to discuss dialysis with their patients prior to involvement of the navigator. However, this often led to delays in care. Better supporting nephrologists in these conversations, potentially by earlier
involvement of the broader care team (navigator, nurses, case managers) may improve pre-dialysis vascular access care.

We used the health system supports of a CKD registry to identify patients potentially ready for vascular access planning, thresholds of eGFR and the 2-year KFRE to establish program eligibility, and a complementary electronic dashboard to monitor patients. While experts have suggested that the KFRE may be valuable in vascular access planning, the KFRE does not account for competing risks such as death and transplant. However, the KFRE does incorporate markers of disease progression (e.g., albuminuria) that offer information beyond eGFR. Use of objective laboratory thresholds to identify eligible patients was key for program implementation as it identified some individuals earlier than if nephrologists were left to act on their own. In addition, the electronic dashboard helped navigators follow-up on missed appointments and new results, facilitating proactive rescheduling and care advancement.

While our study was not designed to assess the relative importance of the intervention components nor powered to detect their impact (individual or collective) on clinical outcomes, our qualitative data suggest that the systematic approach to patient identification and individualized patient education may have been the most impactful program elements. The education component not only addressed patient health information needs, but its related encounters (i.e., educational session, needs and barriers assessment, and navigator follow-ups) offered opportunities to address questions and concerns, often unearthing emotional barriers. Despite these program successes, less than half of participants underwent AV access creation during the project. While reasons for this are likely multi-factorial, we suspect the main drivers were: 1) rolling program enrollment and consequent short program exposure for some patients, 2) short project duration (7 months), and 3) scheduling challenges associated with holidays (November/December 2019) and the COVID-19 pandemic (March 2020). Longer study of this intervention or select components is needed.
We acknowledge that our project has limitations. The QI program was implemented in a semi-closed health system; open systems may face different challenges. However, care and communication are even more cumbersome in open systems, emphasizing the need for structured support programs. Second, enrollment during our 7-month program was rolling, resulting in a relatively short program experience for some participants, limiting our conclusions about outcomes. Third, selection bias may have led to inclusion of patients with weaker care engagement. Specifically, the program included many patients who were eligible for vascular access referral who had either not followed through or declined such a referral. Patients willing to proceed with planning had already had their surgical evaluations and were thus excluded. However, inclusion of patients with lower engagement renders our findings of improved patient education and self-efficacy even more encouraging. Fourth, we assessed patient knowledge and confidence and care team confidence with investigator-developed questionnaires. Results should be interpreted with caution until confirmed in larger studies using validated instruments. Fifth, there may be additional barriers to AV access creation that were not identified in this study. Finally, this was a pilot study without a control group and, was not designed nor powered to evaluate clinical outcomes. Larger randomized-controlled studies investigating the program’s impact on clinical outcomes are needed.

In conclusion, we demonstrated that implementing a program targeting both patient and health system barriers to AV access-based HD initiation was acceptable to participants and may have the potential to improve outcomes. Longer implementations in more diverse health systems are needed.

DISCLOSURES

In the last 2 years, J. Flythe. has received speaking honoraria from the American Society of Nephrology and multiple universities as well as investigator-initiated research funding from the
Renal Research Institute, a subsidiary of Fresenius Kidney Care, North America. J. Flythe. is on the medical advisory board to NxStage Medical, now owned by Fresenius Kidney Care, North America, and has received consulting fees from Fresenius Kidney Care, North America and AstraZeneca. L. Boulware reports Honoraria: Robert Wood Johnson Clinical Scholars Program, Various universities, for visiting professorships; Scientific Advisor or Membership: Robert Wood Johnson Clinical Scholars National Advisory Committee, Association for Clinical and Translational Science, Journal of the American Medical Association – Editorial Board, Journal of the American Medical Association Network Online - Editorial Board. J. Pendergast reports Honoraria: NIH NIA/NIMH Advanced Research institute (ARI) for training junior scholars to get their first R01; ($1000 for 3 days of mentoring). S. Peskoe reports Other Interests/Relationships: JAMA Network Open - Statistical Reviewer. The remaining authors have nothing to disclose.

FUNDING

This work was supported by National Institute of Diabetes, Digestive and Kidney Diseases (NIDDK) grant R21 DK116115 to Flythe, Boulware, Green, Pendergast, and Peskoe. In addition, Dr. Flythe is supported by NIDDK grant K23 DK109401.

ACKNOWLEDGEMENTS

The results presented in this article have not been published previously in whole or part, except in abstract form.

AUTHOR CONTRIBUTIONS

J Flythe: Conceptualization; Data curation; Funding acquisition; Investigation; Methodology; Project administration; Supervision; Writing - original draft; Writing - review and editing

J Narendra: Data curation; Project administration; Writing - review and editing

S Manivannan: Formal analysis; Writing - review and editing

S Murphy: Formal analysis; Writing - review and editing

S-Y Lee: Methodology; Writing - review and editing

T Strigo: Funding acquisition; Project administration; Writing - review and editing

Flythe, J.E., et al. 18
REFERENCES

1. Vascular Access Workgroup. Clinical practice guidelines for vascular access. Am J Kidney Dis 2006; 48 Suppl 1: S176-247.

2. Jindal K, Chan CT, Deziel C, et al. Hemodialysis clinical practice guidelines for the Canadian Society of Nephrology. J Am Soc Nephrol 2006; 17: S1-27.

3. Tordoir J, Canaud B, Haage P, et al. EBPG on Vascular Access. Nephrol Dial Transplant 2007; 22 Suppl 2: ii88-117.

4. Ravani P, Gillespie BW, Quinn RR, et al. Temporal risk profile for infectious and noninfectious complications of hemodialysis access. J Am Soc Nephrol 2013; 24: 1668-1677.

5. Ravani P, Palmer SC, Oliver MJ, et al. Associations between hemodialysis access type and clinical outcomes: a systematic review. J Am Soc Nephrol 2013; 24: 465-473.

6. Lok CE, Huber TS, Lee T, et al. KDOQI Clinical Practice Guideline for Vascular Access: 2019 Update. Am J Kidney Dis 2020; 75: S1-S164.

7. Allon M, Dinwiddie L, Lacson E, et al. Medicare reimbursement policies and hemodialysis vascular access outcomes: a need for change. J Am Soc Nephrol 2011; 22: 426-430.

8. United States Renal Data System. 2018 USRDS Annual Data Report: Epidemiology of Kidney Disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2018.

9. End Stage Renal Disease National Coordinating Center: Fistula First Catheter Last. Available at https://esrdncc.org/en/fistula-first-catheter-last. Accessed 12/15/2020.

10. Lok CE. Fistula first initiative: advantages and pitfalls. Clin J Am Soc Nephrol 2007; 2: 1043-1053.

11. Lopez-Vargas PA, Craig JC, Gallagher MP, et al. Barriers to timely arteriovenous fistula creation: a study of providers and patients. Am J Kidney Dis 2011; 57: 873-882.
12. Woo K, Lok CE. New Insights into Dialysis Vascular Access: What Is the Optimal Vascular Access Type and Timing of Access Creation in CKD and Dialysis Patients? *Clin J Am Soc Nephrol* 2016; 11: 1487-1494.

13. Kiaii M, MacRae JM. A dedicated vascular access program can improve arteriovenous fistula rates without increasing catheters. *J Vasc Access* 2008; 9: 254-259.

14. Casey JR, Hanson CS, Winkelmayer WC, et al. Patients' perspectives on hemodialysis vascular access: a systematic review of qualitative studies. *Am J Kidney Dis* 2014; 64: 937-953.

15. Taylor MJ, Hanson CS, Casey JR, et al. "You know your own fistula, it becomes a part of you"—Patient perspectives on vascular access: A semistructured interview study. *Hemodial Int* 2016; 20: 5-14.

16. Gale RC, Kehoe D, Lit YZ, et al. Effect of a Dialysis Access Coordinator on Preemptive Access Placement among Veterans: A Quality Improvement Initiative. *Am J Nephrol* 2017; 45: 14-21.

17. Navaneethan SD, Jolly SE, Schold JD, et al. Pragmatic Randomized, Controlled Trial of Patient Navigators and Enhanced Personal Health Records in CKD. *Clin J Am Soc Nephrol* 2017; 12: 1418-1427.

18. Kosa SD, Bhola C, Lok CE. Hemodialysis patients' satisfaction and perspectives on complications associated with vascular access related interventions: are we listening? *J Vasc Access* 2016; 17: 313-319.

19. Owen JE, Walker RJ, Edgell L, et al. Implementation of a pre-dialysis clinical pathway for patients with chronic kidney disease. *Int J Qual Health Care* 2006; 18: 145-151.

20. Polkinghorne KR, Seneviratne M, Kerr PG. Effect of a vascular access nurse coordinator to reduce central venous catheter use in incident hemodialysis patients: a quality improvement report. *Am J Kidney Dis* 2009; 53: 99-106.

21. Glazer S, Diesto J, Crooks P, et al. Going beyond the kidney disease outcomes quality initiative: hemodialysis access experience at Kaiser Permanente Southern California. *Ann Vasc Surg* 2006; 20: 75-82.

22. Ackad A, Simonian GT, Steel K, et al. A journey in reversing practice patterns: a multidisciplinary experience in implementing DOQI guidelines for vascular access. *Nephrol Dial Transplant* 2005; 20: 1450-1455.

23. Fishbane S, Agoritsas S, Bellucci A, et al. Augmented Nurse Care Management in CKD Stages 4 to 5: A Randomized Trial. *Am J Kidney Dis* 2017; 70: 498-505.

24. Green JA, Ephraim PL, Hill-Briggs FF, et al. Putting patients at the center of kidney care transitions: PREPARE NOW, a cluster randomized controlled trial. *Contemp Clin Trials* 2018; 73: 98-110.
25. Ogrinc G, Davies L, Goodman D, et al. SQUIRE 2.0 (Standards for QUality Improvement Reporting Excellence): revised publication guidelines from a detailed consensus process. BMJ Qual Saf 2016; 25: 986-992.

26. Tangri N, Stevens LA, Griffith J, et al. A predictive model for progression of chronic kidney disease to kidney failure. JAMA 2011; 305: 1553-1559.

27. Tangri N, Grams ME, Levey AS, et al. Multinational Assessment of Accuracy of Equations for Predicting Risk of Kidney Failure: A Meta-analysis. JAMA 2016; 315: 164-174.

28. Wild MG, Wallston KA, Green JA, et al. The Perceived Medical Condition Self-Management Scale can be applied to patients with chronic kidney disease. Kidney Int 2017; 92: 972-978.

29. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. Qual Health Res 2005; 15: 1277-1288.

30. Moser A, Korstjens I. Series: Practical guidance to qualitative research. Part 3: Sampling, data collection and analysis. Eur J Gen Pract 2018; 24: 9-18.

31. SAS Institute, Inc.: SAS/STAT\textsuperscript{(c)} 15.1 User’s Guide. Cary, NC, 2018.

32. R Code Team: A language and environment for statistical computing. R Foundation for Statistical Computing. Vienna, Austria, 2020.

33. Xuan Chia JM, Goh ZS, Seow PS, et al. Psychosocial Factors, Intentions to Pursue Arteriovenous Dialysis Access, and Access Outcomes: A Cohort Study. Am J Kidney Dis 2020. In press.

34. Dumaine C, Kiaii M, Miller L, et al. Vascular Access Practice Patterns in Canada: A National Survey. Can J Kidney Health Dis 2018; 5: 2054358118759675.

35. Ethier JH, Lindsay RM, Barre PE, et al. Clinical practice guidelines for vascular access. Canadian Society pf Nephrology. J Am Soc Nephrol 1999; 10 Suppl 13: S297-305.

36. Inston N, Lok CE. Improving precision in prediction: Using kidney failure risk equations as a potential adjunct to vascular access planning. J Vasc Access 2019; 20: 95-97.

37. Hemmelgarn BR, Manns BJ, Quan H, et al. Adapting the Charlson Comorbidity Index for use in patients with ESRD. Am J Kidney Dis 2003; 42: 125-132.
Table 1. Vascular access clinical support program components.

| Component                                | Purpose                                | Description                                                                                                                                                                                                 |
|------------------------------------------|----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Vascular access-specific education       | Improve vascular access knowledge      | • Individual or small group sessions dedicated to vascular access education (in-person, telephone)                                                                                                                 |
|                                          |                                        | • Content                                                                                                                                                                                                   |
|                                          |                                        | ▪ Vascular access types and related terms                                                                                                                                                                 |
|                                          |                                        | ▪ Associated care process steps                                                                                                                                                                          |
|                                          |                                        | ▪ Acknowledgement of common emotions and complications                                                                                                                                                    |
|                                          |                                        | • Materials: investigator-developed and AAKP brochures                                                                                                                                                     |
| Needs and barriers assessment            | Identify barriers to vascular access care and provide targeted resources | • Assessment of financial, transportation, emotional, and other barriers to vascular access care, assessment of preferred communication mode, and provision of appropriate resources (referrals, support, etc.) |
|                                          |                                        | • Opportunity to reinforce vascular access education content                                                                                                                                             |
| Peer mentoring                           | Provide emotional support and practical care navigation tips | • Peer-to-peer supportive interaction (in-person, telephone, email)                                                                                                                                          |
|                                          |                                        | • Frequency and mode of interaction selected by mentees and mentors                                                                                                                                         |
|                                          |                                        | • Mentors underwent vascular access education and peer mentorship training prior to mentee connection                                                                                                      |
| Vascular access care navigation         | Provide care coordination support       | • Identify patients in need of vascular access planning and secure nephrologist agreement for patient enrollment                                                                                          |
|                                          |                                        | • Facilitate care coordination, appointment scheduling and reminders, and peer mentor program enrollment                                                                                               |
|                                          |                                        | • Prompt providers to communicate with each other                                                                                                                                                          |
|                                          |                                        | • Address patient questions and concerns and provide education reinforcement                                                                                                                               |
| Vascular access-specific electronic dashboard | Enable efficient patient monitoring and care planning | • Enable monitoring of patients through vascular access care steps                                                                                                                                           |
|                                          |                                        | • Organized by care step to facilitate identification of upcoming or missed appointments, unscheduled referrals, and study results                                                                       |

Abbreviations: AAKP, American Association of Kidney Patients.
### Table 2. Illustrative quotations about barriers to pre-dialysis vascular access care from focus group and interview participants.\(^a\)

| Patient barriers                                                                 | Health system barriers                                                                 |
|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| **Experiencing negative emotions**                                               | **Poor inter-provider communication**                                                  |
| *Fear*                                                                          | *Access Center Nurse:* “You've got the nephrologists in this medical record, the access center in that record, the surgeon in another. You've got a lot of turning wheels in one patient, and the doctors are not on the same page.”
| CKD Patient: “I was worried and angry as all heck [when I found out I needed dialysis].” | *Interventionalist:* “I think multiple specialties working collaboratively to deliver a service is important.”
| CKD Patient: “The thing is I don't really want to talk about it. No, I haven't talked about it yet. I had an appointment at one time. I just didn't go because I was scared.” | *Lack of a centralized approach to care navigation and patient monitoring*              |
| Dialysis Patient: “There's worry your life is changing. There's worry about the surgery itself.” | **CKD Patient:** “I'll tell you though, it's hard getting through to anybody in the hospital anymore. You call, and you get switched all around.”
| *Denial*                                                                        | *Care Partner:* “His vascular surgeon is at so many different sites, he never has time to keep track of you.”
| CKD Patient: “When I first heard about [needing AV access], it actually made me not want to come back. So, I just shut it off. I just didn't want to face it, so I didn't go.” | *Nephrology clinic nurse:* “I think the biggest barrier is that there's not someone guiding them through the process... there's a lot of follow-up that has to happen, and there's not one person guiding that sort of journey.”
| CKD Patient: “I'm trying to avoid it (follow up for his AV access).”             | *Surgeon:* “They have a hard time navigating the healthcare system. It's often a multistep process. You see your nephrologist, you get your mapping, you see your surgeon, you get a surgery date, you might have something else in between. So, all those little things, you know, if there's someone who is identifying all these little bumps in the road and getting the patients through them, that would be helpful.”
| Surgeon: “[Patients] kind of want to ignore it until they're admitted with a catheter. They might've even been someone we saw, who's like: ‘Yeah, I don't know, I'll call you back. I'm not sure I want surgery next week. I'll get back to you about that.' They typically don't get back to us till they're on dialysis.” | *Interventionist:* “I think multiple specialties working collaboratively to deliver a service is important.”
| *Uncertainty*                                                                   | *Lack of a centralized approach to care navigation and patient monitoring*              |
| CKD Patient: “Anything unfamiliar to you, you tend to worry and dread it coming. You know it's got to happen, but it doesn't make it any better.” | **CKD Patient:** “I'll tell you though, it's hard getting through to anybody in the hospital anymore. You call, and you get switched all around.”
| CKD Patient: “I constantly worry that I'm going to, like, in life, you know, you just bump my arm, or fall. I don't know how fragile that [fistula] is, like how much I should be worried.” | *Care Partner:* “His vascular surgeon is at so many different sites, he never has time to keep track of you.”
| Dialysis Patient: “Oh man, just the stress, like to kill me. Because, you just don't know really what's going to happen.” | *Nephrology clinic nurse:* “I think the biggest barrier is that there's not someone guiding them through the process... there's a lot of follow-up that has to happen, and there's not one person guiding that sort of journey.”
| Nephrology Clinic Nurse: “It's very difficult for people to make those decisions, and there's always the hope that their kidneys are going to recover.” | *Surgeon:* “They have a hard time navigating the healthcare system. It's often a multistep process. You see your nephrologist, you get your mapping, you see your surgeon, you get a surgery date, you might have something else in between. So, all those little things, you know, if there's someone who is identifying all these little bumps in the road and getting the patients through them, that would be helpful.”
| *Having inadequate vascular access and dialysis knowledge*                      | *Interventionist:* “I think multiple specialties working collaboratively to deliver a service is important.”
| CKD Patient: “If I could have gotten more information on what to expect after the fistula was done. Maybe that would have helped me feel a little more reassured.” | *Lack of a centralized approach to care navigation and patient monitoring*              |
| Dialysis Patient: “I took the Kidney Smart Class, and they did touch on [AV access], but not enough to really let you know what you were getting into.” | **CKD Patient:** “I'll tell you though, it's hard getting through to anybody in the hospital anymore. You call, and you get switched all around.”
| Caregiver: “See his [fistula] was in, but his kidneys went that fast. There wasn’t time for it to mature, and he had to get the catheter. There was no head’s up that something like that might happen... Things happen. There’s going to be hiccups along the way- having the conversation about things like that is good. But you don’t hear that.” | *Care Partner:* “His vascular surgeon is at so many different sites, he never has time to keep track of you.”
| Surgery Nurse: “A large majority of the time, [patients] have no idea why they're here. They have no idea what a fistula is. They have no idea what a graft is.” | *Nephrology clinic nurse:* “I think the biggest barrier is that there's not someone guiding them through the process... there's a lot of follow-up that has to happen, and there's not one person guiding that sort of journey.”
| Access Center Nurse: “When they get to me [vessel mapping], they don't even know the difference between a fistula and a graft, and some people think they will have stuff hanging out of their arm. There's very little education.” | *Surgeon:* “They have a hard time navigating the healthcare system. It's often a multistep process. You see your nephrologist, you get your mapping, you see your surgeon, you get a surgery date, you might have something else in between. So, all those little things, you know, if there's someone who is identifying all these little bumps in the road and getting the patients through them, that would be helpful.”

\(^a\) Focus group participants included patients and care partners. Interview participants included nephrologists; surgeons; interventionalists; and nephrology, surgery, and radiology clinic nurses and schedulers.

Abbreviations: AV, arteriovenous; CKD, chronic kidney disease.
Table 3. Characteristics of vascular access quality improvement program participants.

| Characteristic                                      | QI program | Research sub-study |
|-----------------------------------------------------|------------|--------------------|
| **Patients**                                        | *N*=37     | *N*=21             |
| Age (years)                                         | 63 [58, 74]| 67 [55, 74]        |
| Female                                              | 12 (32)    | 5 (24)             |
| Race                                                |            |                    |
| Black                                               | 1 (3)      | 0                  |
| White                                               | 36 (97)    | 21 (100)           |
| Highest level of education completed                |            |                    |
| Less than high school                               | 1 (5)      |                    |
| High school graduate or GED                         | 10 (47)    |                    |
| Some college                                        | 5 (23)     |                    |
| 4-year college degree or more                       | 4 (20)     |                    |
| Missing                                             | 1 (5)      |                    |
| Insurance type                                      |            |                    |
| Geisinger Health Plan                               | 18 (49)    | 8 (38)             |
| Other private or commercial plan                    | 6 (16)     | 3 (14)             |
| Medicare                                            | 11 (30)    | 8 (38)             |
| Self-pay                                            | 1 (3)      | 1 (5)              |
| Other                                               | 1 (3)      | 1 (5)              |
| Charlson Comorbidity Index                          | 7 [5, 8]   | 7 [5, 8]           |
| Diabetes                                            | 24 (65)    | 15 (71)            |
| KFRE score (%)                                      | 40 [10, 60]| 0.4 [0.1, 0.6]     |
| Estimated GFR (mL/min/1.73m²)                       | 20 [17, 22]| 19 [17, 23]        |
| Distance from home to nephrology clinic (miles)     | 18 [13, 23]| 18 [13, 23]        |
| Duration of nephrology care (months)                | 37 [14, 93]| 66 [25, 147]       |
| (+) Hospitalization in 90 days prior                | 5 (14)     | 4 (19)             |

**Medical providers and clinic personnel**

| Characteristic                                      | *N*=32     | *N*=25             |
| Age (years)                                         | ---        | 38 [35, 42]        |
| Female                                              | 14 (44)    | 12 (48)            |
| Race                                                |            |                    |
| Black                                               | 0          | 0                  |
| White                                               | 26 (81)    | 22 (88)            |
| Other                                               | 6 (19)     | 3 (12)             |
| Professional role                                   |            |                    |
| Nephrologist                                        | 8 (25)     | 8 (32)             |
| Surgeon                                             | 14 (44)    | 10 (40)            |
| Interventional radiologist                          | 6 (19)     | 3 (12)             |
| Nephrology clinic nurse                             | 2 (6)      | 2 (8)              |
| Case manager                                        | 2 (6)      | 2 (8)              |
| Time in current role (years)                        | ---        | 7 (28)             |
| ≤1                                                  |            |                    |
| 2-4                                                 |            |                    |
| ≥5                                                  |            |                    |
| Time working with vascular access (years)           | ---        |                    |
| ≤1                                                  |            | 2 (8)              |
| 2-4                                                 |            | 6 (24)             |
| ≥5                                                  |            | 17 (68)            |

*a* Participant characteristics at time of QI program enrollment. Values are presented as n (%) or median [interquartile range].

**Abbreviations**: GED, General Educational Development; GFR, glomerular filtration rate; IQR, interquartile range; KFRE, kidney failure risk equation; QI, quality improvement.
| Identified barriers (Pre- and intra-program) | Responsive changes | Remaining barriers (Post-program) | Future recommendations |
|---------------------------------------------|--------------------|-----------------------------------|-----------------------|
| Program eligibility criteria and enrollment | • Changed threshold to eGFR <25 mL/min/1.73m² | [Post-] Eligibility threshold of eGFR <25 mL/min/1.73m² to prompt consideration | • Continue to alert nephrologists to patients with eGFR <25 mL/min/1.73m² |
| [Pre-] Eligibility threshold of eGFR <20 mL/min/1.73m² felt to be too restrictive and could lead to missed opportunities for early education | • Ensured that navigators contacted nephrologists before approaching patients about program enrollment | [Post-] Paper notices improved communication/provider awareness, but more communication needed | • Use referral to modality education class as trigger to enroll patients in the vascular access program |
| [Intra-] Nephrologists wanted to speak to patients about vascular access prior to navigator contacting patients | • ↑ EHR message use and ↓ in-person meetings | | • Obtain stronger nephrologist buy-in pre-program |
| [Intra-] Difficult for navigators to meet in-person with nephrologists to discuss program-eligible patients | • Placed paper notices on exam room doors of eligible patients to remind nephrologists to discuss | | • Give medical providers access to electronic dashboard |
| Vascular access-specific patient education | [Pre-] Need for standardized education | [Post-] Patients and care partners desired supplemental education video and more patient testimonials | • Develop video to complement written materials |
| | • Developed education session facilitator guide | | • Encourage use of peer mentoring program |
| | • Developed handout with resource weblinks | | |
| | • Shifted to telephone-based education sessions | | |
| Peer mentoring | [Pre-] Concern that a national peer mentoring program (with mentor telephone access) would not be utilized | [Post-] Mentor training did not have enough time for mock mentee interactions | • Increase time for peer mentor training |
| | • Developed local peer mentor program | | |
| | • Tailored program to vascular access by equipping mentors with lists of common barriers to vascular access care and frequently asked questions | | |
| | • Developed vascular access education “refresher” that was provided to mentors prior to mentee matching | | |
| | [Post-] One mentee did not “match” with a mentor | | • Add option to participate in a national peer program |
| Needs and barriers assessment | | | |

Flythe, J.E., et al. 25
| [Pre-] Potential overlap with existing needs assessment | • Adapted existing assessment to incorporate barriers relevant to vascular access and established thresholds of responses for resource provision |
|---|---|
| **Vascular access care navigation** | |
| [Pre-] Concern about a heavy workload for navigators | • Trained 3 clinic personnel (case managers, nurses) so duties could be shared, and back-up provided |
|  | [Post-] Duties can be time-consuming if added to additional non-navigator job responsibilities |
|  | • Incorporate vascular access navigator responsibilities with those of a CKD navigator (1 FTE) |
| **Vascular access-specific electronic dashboard** | |
| [Intra-] Difficult and time-consuming to prioritize potentially eligible patients | • Created filters by which list could be sorted (eligible, ineligible, need further review, etc.) |
|  | [Post-] Only the navigators used the dashboard |
|  | • Give medical providers access to dashboard |

* Barriers were ascertained from pre-, intra-, and post-QI program implementation interviews with patients, care partners, medical providers, and clinic personnel participating in the program. [Pre-], [Intra-], and [Post-] denote timing of barrier identification.

**Abbreviations:** CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; EHR, electronic health record; FTE, full time equivalent; QI, quality improvement.
**Figure 1.** Project activities.

*Abbreviations: EHR, electronic health record; QI, quality improvement.*
In addition to the displayed patient QI and research sub-study participants, there were 32 medical provider/personnel QI participants and 25 medical provider/personnel research sub-study participants.

The EHR population-based kidney disease registry (i.e., continually updated electronic list, called the 'Kidney Transitions Registry') incorporates an automated risk prediction tool (KFRE) alongside the Geisinger EHR platform. Outpatient data from the EHR are processed nightly to identify qualifying patients. The KFRE is a well-validated algorithm designed to help providers identify individuals with a high predicted risk of developing kidney failure within 2 years based on their age, sex, eGFR, urine albumin-to-creatinine ratio, calcium, phosphorus, albumin, and bicarbonate).26, 27

Assessment ongoing at the end of the program indicates that the navigator was awaiting nephrologist approval for program enrollment. In many cases, nephrologists were waiting for an upcoming appointment to discuss the program with the patient prior to agreeing to program enrollment.

Abbreviations: AV, arteriovenous; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; EHR, electronic health record; KFRE, Kidney Failure Risk Equation; QI, quality improvement.
Figure 3. Patient and care-team reported outcomes before and after program implementation.\textsuperscript{a}

\textsuperscript{a} Scores from the 16 patients and 23 providers/clinic personnel who completed both pre- and post-program surveys are reported as means. Differences in pre- and post-program scores were assessed with paired T-tests.