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## Review article

# In-home vascular testing program during the COVID-19 pandemic

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## ARTICLE INFO

## ABSTRACT

This is a retrospective review of a pilot program to provide in home vascular testing to patients during the COVID-19 Pandemic. Results: Eighty-four patients underwent a total of 105 vascular imaging tests as part of the program. Two patients required hospitalization secondary to imaging findings. A description of the program, the results of the testing and patient experience with in-home vascular testing is discussed.

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## 1. Introduction

As the coronavirus disease 2019 (COVID-19) pandemic spread across the world and the United States, physicians were forced to modify their office practices to decrease the risk of viral spread. Changes were made to protect patients and staff by cancelling testing and office visits or converting them to virtual visits. Although virtual visits provide a good alternative in many situations, they are inherently limited. For vascular surgery patients, vascular laboratory tests, such as carotid duplex, abdominal aortic aneurysm duplex, and ankle brachial indices, are necessary to adequately assess and manage their conditions. As the pandemic spread, stay-at-home orders were put into effect, limiting outpatient services. Even when travel for medical appointments was not restricted, elderly patients and their families were afraid of traveling to medical centers where they could be exposed to the virus. To provide care to these patients, minimize their risks of travel, and alleviate their anxiety regarding their vascular disease, we implemented an in-home vascular testing (IHVT) program.

## 2. Methods

This study was a retrospective review of a pilot in-home vascular testing program to assess the feasibility and outcomes of an IHVT program during the COVID-19 pandemic and stay-at-home order. Data collection occurred April 1, 2020 through May 7, 2020. Those younger than 18 years and those unable to consent on their own were excluded. Most of the participants were undergoing studies for follow-up of prior interventions, many of which had surgery just before the onset of the pandemic and the executive stay-at-home order. It was felt these patients were at higher risk if their studies were postponed for several months. Routine follow-up studies on stable patients were not considered for this program unless the physician specifically requested it be performed. Several new patients referred to our office for potential symptomatic carotid disease, peripheral vascular disease with ulcerations and newly diagnosed aneurysm participated in the in-home program. [Figure 1](#) shows a schematic of the program including the roles and duties of each person.

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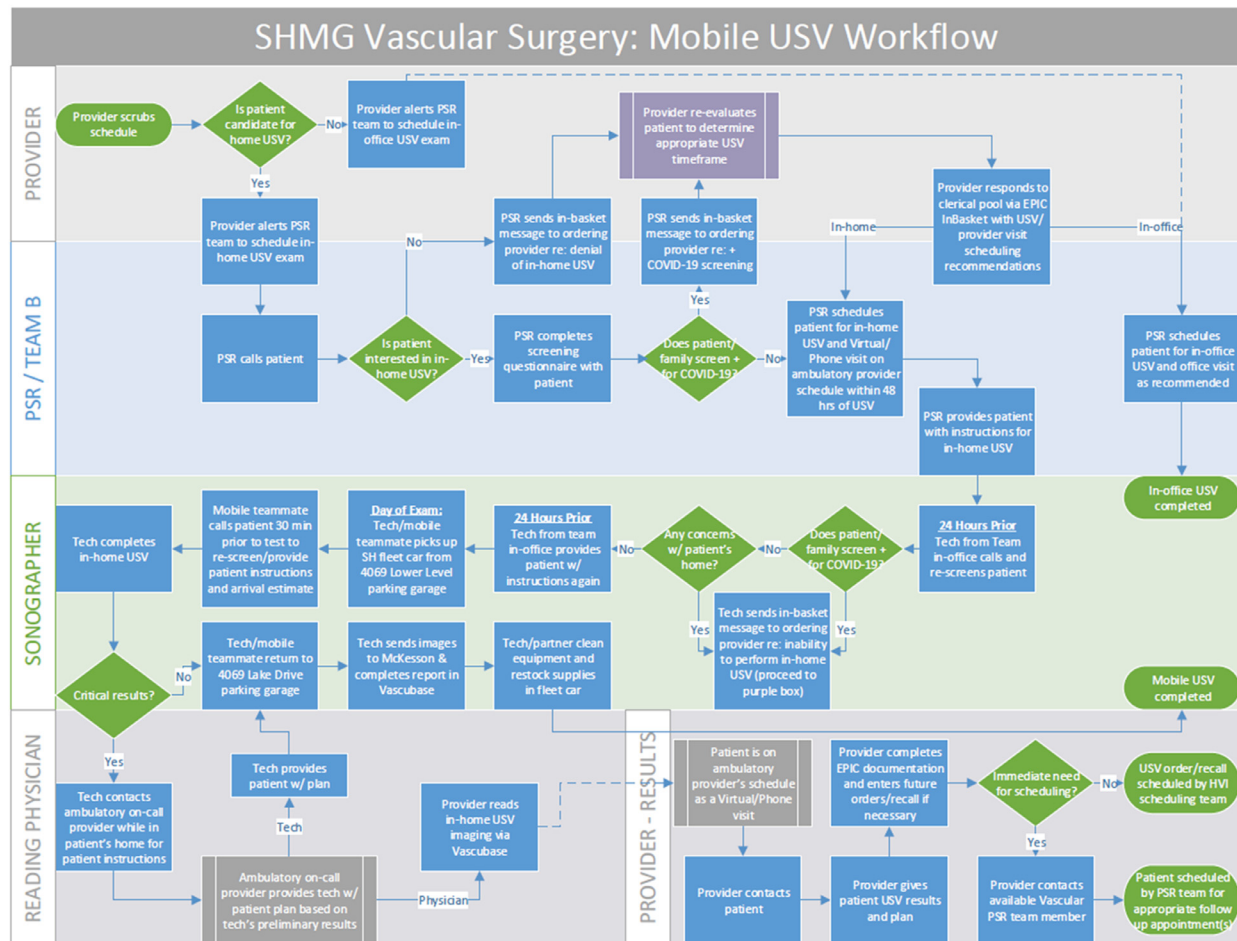


Fig. 1 – Diagrammatic flowsheet for in-home vascular testing program.

A total of 98 participants were initially screened and recruited. Of the 98 potential participants, 84 elected to proceed with the IHVT. Of the 84 IHVT participants, we received 52 completed surveys. Patients were screened as possible candidates for IHVT through review of their upcoming appointment, testing needs, and home location in the electronic medical record per our protocol. Those who were believed to be at high risk for complications due to their vascular disease (eg, vulnerable bypass grafts, enlarging aneurysms, moderate- to high-grade carotid stenosis, or recent postoperative patients) were given priority. High-risk comorbidities were also considered and defined as those with diagnoses of chronic obstructive pulmonary disease, congestive heart failure, renal insufficiency defined as a glomerular filtration rate <60 mL/min, obesity defined as a body mass index  $\geq 30$ , current tobacco use, history of malignancy, and diabetes mellitus. These comorbidities are summarized in Table 1.

Those who were interested in participating underwent COVID-19 symptom screening via a phone call for themselves and persons living with them at the time of initial scheduling, within 24 hours of appointment, and within 30 minutes of the appointment. If anyone in the home answered positively to the screening questions, testing was not

scheduled/cancelled. Testing was performed by two Intersocietal Accreditation Commission-credentialed registered vascular technologists. The sonographers were screened daily for symptoms of COVID-19 in accordance with our institutional policies. On arrival, both the sonographers showed the patient and family proof of passing the COVID-19 symptoms screening questionnaire. They then sanitized their hands and donned appropriate personal protective equipment (PPE) which included masks, gowns, gloves, and shoe covers, before entering the patient's home. Family members and patients were also offered masks if they desired to have additional protection. We requested family members maintain a 6-foot distance from the patient and sonographers throughout the visit. Upon completion of testing, all PPE was bagged and sealed. The bag was disposed of in the patient's trash at home.

The ultrasound studies were performed using a Philips CX-50 portable Ultrasound unit. Arterial physiologic studies were performed using a Vasculab Portable machine (US Vascular). From an ergonomic standpoint, mobile carts were used to transport the equipment between the vehicle and patient home. Studies were performed with the patient lying on a bed, couch, or recliner, when possible, and the sonographer using a

**Table 1 – Participant demographic characteristics.**

Characteristic	Data
Sex, n (%)	
Male	57 (68)
Female	27 (32)
Age, n (%)	
Younger 60 y	13 (15)
60 to 70 y	31 (37)
70 to 80 y	24 (29)
Older than 80 y	16 (19)
Chronic obstructive pulmonary disease, n (%)	20 (24)
Congestive heart failure, n (%)	15 (18)
Hypertension, n (%)	65 (77)
Renal insufficiency (glomerular filtration rate $\leq$ 60 mL/min, n (%))	18 (21)
Obesity (body mass index $\geq$ 30), n (%)	44 (52)
Tobacco use (current), n (%)	20 (24)
History of malignancy, n (%)	13 (15)
Diabetes mellitus, n (%)	31 (28)
No. of comorbidities, n	
0	6
1	6
2	26
3	24
4	26
5	7
6	5

chair. The two sonographers alternated scanning patients and performing the machine adjustments to minimize risk of injury due to potential ergonomic compromise. All studies were performed using the same protocols as in our office-based vascular laboratory without the need to modify any protocols. Our institution provided a vehicle appropriate for transporting the equipment and we were able to divert PPE from our vein center, which was closed due to the pandemic, for use in the program.

The survey provided to our patients can be viewed in [Figure 2](#). Each survey consisted of eight statements with selection choices ranked from 1 to 5, with 1 being strongly agree and 5 being strongly disagree. Patients that underwent IHVT were asked to complete this short survey after they had signed informed consent for participation in this study. Patients were sent a printed survey in the mail. Instructions were provided with included prepaid return envelopes after their scheduled in-home testing date.

### 3. Results

A total of 98 patients were identified as potential candidates. Of these 98 patients, 14 (14%) either declined in-home testing or could not be contacted after multiple attempts to schedule. Between April 1, 2020 and May 7, 2020, a total of 84 patient, 27 female and 57 male, underwent successful in-home testing. Of the 84 patients, 52 (62%) completed the post in-home testing survey. Patient demographic characteristics, which included sex, age, and comorbidities can be seen in [Table 1](#). Patients

**Table 2 – Tests performed.**

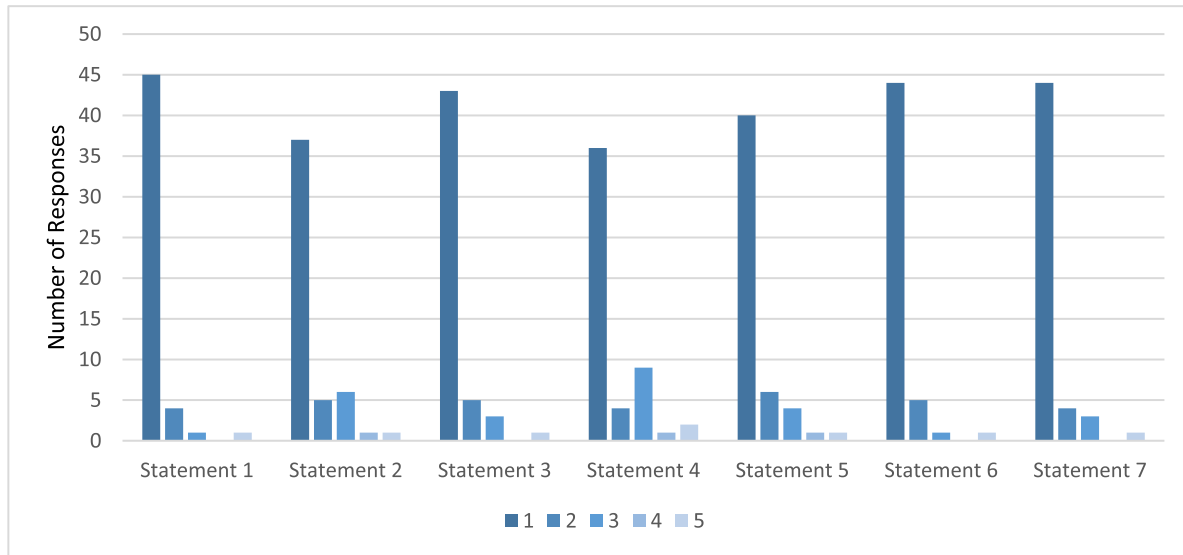
Test	n (%)
Lower extremity physiologic testing	46 (44)
Carotid duplex ultrasound	20 (19)
Lower extremity arterial duplex ultrasound	18 (17)
Abdominal aorta ultrasound	14 (13)
Lower extremity venous duplex ultrasound	2 (2)
Mesenteric duplex ultrasound	2 (2)
Renal artery duplex ultrasound	1 (1)
Dialysis access duplex ultrasound	1 (1)
Upper extremity physiologic testing	1 (1)
Total	105 (100)

were further subdivided into groups based on the number of comorbid diagnoses they had received. Eighty-eight percent of the participants were found to have two or more comorbid diagnoses and 76% of the participants had two to four comorbid diagnoses. Hypertension was the most common comorbid condition, found in 77% of our patients.

A total of 105 tests were performed on our patient population. A breakdown of the types and numbers of tests performed can be seen in [Table 2](#). Lower extremity physiologic, carotid duplex, lower extremity arterial duplex, and abdominal aorta ultrasound testing comprised the top four tests, making up 93% of the tests performed. Lower extremity physiologic testing was the number one test performed, making up 44% of the tests. Of note, 4 of the 105 tests demonstrated critical findings. This resulted in hospital admission of two of the patients.

We collected 52 surveys from the 84 participants, and the combined scoring/comments were documented. The responses are summarized in [Tables 3](#) and [4](#). Each survey consisted of eight statements, with selection choices ranked from 1 to 5 (1 = strongly agree and 5 = strongly disagree). The first seven statements on the questionnaire considered the convenience, ease, safety, efficiency, transparency, likely future usage, and likely recommendation to other patients of IHVT. Of the 52 surveys mailed back, the average response rate to each question was 98.9%. Of the surveys received, most participants responded with strongly agree to the first 7 statements. Question 4 measured the lowest at 69.2%, which pertained to patient's concern of their vascular problems. Four of the seven questions in [Table 3](#) measured  $\geq$ 82% to the strongly agree statement. A summary of the data from [Table 3](#) can be seen in [Figure 3](#). Statement 8 reflected on how participants would have sought out their vascular care if in-home testing was not available during COVID-19. Of the 49 responses, 63.5% of participants would have driven to the office for vascular testing and 23.1% of participants preferred to cancel their appointment in the office and delay their vascular testing.

Finally, we have included financial data from our institution, comparing the same time frame from 2019 and 2020. [Table 5](#) summarizes these data. We noted an overall decrease of 80% in the number of patients and tests performed, with a loss of \$399,015 (a decrease of 82%) in gross billings for April 2020 compared to April 2019. The IHVT program accounted



**Fig. 2 – Survey questions for in-home vascular testing program.**

**Survey Questions for In-Home Vascular Testing Program**

Thank you for participating in the pilot program for the Spectrum Health Medical Group Vascular Surgery In-Home Vascular Ultrasound Testing. The COVID-19 pandemic has disrupted lives of our patients, staff, and caregivers. We started this program to help provide testing to patients that we felt were at high risk for problems from their vascular disease and at risk for pulmonary complications if exposed to COVID-19 and mitigate the effects this virus is having on our patients. We are looking for your feedback to help determine if this was a safe and worthwhile project as well as to look for ways to improve it.

For each of the statements, please rank your answer by this scale:

1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree

1. The scheduling process for the in-home testing was easy and straight forward.

1 2 3 4 5

2. I appreciated the COVID symptom Screening being done prior to the visit schedule and prior to the arrival of the vascular sonographers to my home.

1 2 3 4 5

3. I felt safe having the testing performed in my home.

1 2 3 4 5

4. Having in-home testing during the COVID-19 pandemic and stay-at-home order made me less worried about my vascular problems.

1 2 3 4 5

5. The process for receiving results was explained and occurred as described.

1 2 3 4 5

6. I would have the in-home testing again if available.

1 2 3 4 5

7. I would recommend having the in-home testing to other patient

1 2 3 4 5

8. If the in-home testing were not available, which option would you have chosen:

a. Drive to the office for testing

b. Cancel testing appointment at office and wait until COVID-19 epidemic or stay-at-home order was over.

c. Other (please comment below)

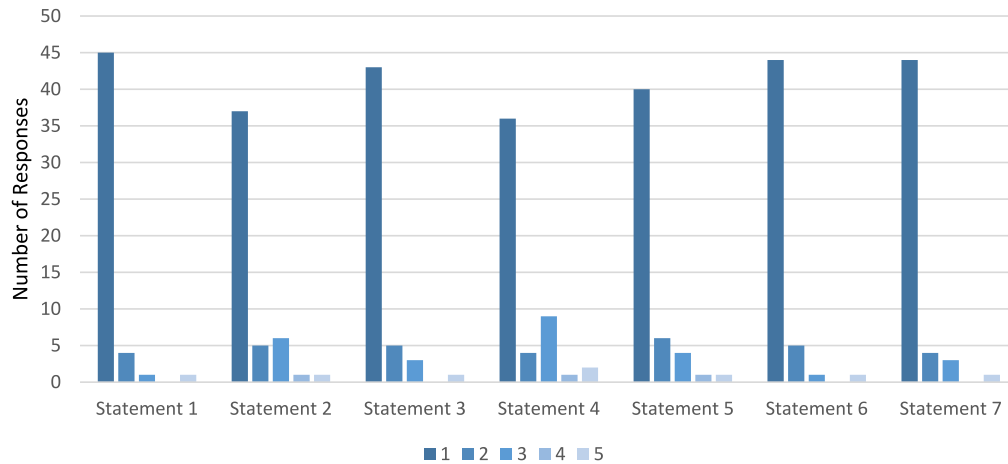
Other:

for 49% of the total patients, tests, and gross charges for April 2020.

**4. Discussion**

The COVID-19 pandemic has significantly impacted all specialties when it comes to inpatient and outpatient care. The

ability to receive nonemergent vascular care was limited by patient fear of traveling to medical centers where they could be exposed to COVID-19, closing of medical offices and hospitals to all but emergent care, and statewide shelter-in-place orders. Although telephone encounters and virtual visits can help identify symptomatic patients, many vascular conditions require imaging studies to safely monitor and make appropri-



**Fig. 3 – Bar graph representation of Table 3.**

ate decisions. We created an IHVT program to allow patients to undergo their needed vascular testing while in the safety of their home.

Application of telemedicine or remote clinical encounters in vascular surgery is a topic that has limited published literature. Although limited, because of the current medical environment and the likely lasting impact, it seems remote clinical encounters or telemedicine will likely have a place in the future of outpatient vascular medicine. This change was alluded to in an article published in 2013 [1]. After data collection for 13 years, the investigators concluded telemedicine, meaning e-mail consultations, will increase in popularity and importance for outpatient vascular surgery practices. This study provides a framework for our research because it accurately predicted a change we are familiar with today. E-mail is a tool we use regularly in direct communication with patients and colleagues. There are other applications of telemedicine currently being investigated. Multiple studies have looked at the use of photograph-based telemedicine in the setting for monitoring postoperative wound assessments. One found remote investigators consistently rated wounds on the ASEPSIS scale (wherein points are given for the need for additional treatment, the presence of serous discharge, erythema, purulent exudate, separation of the deep tissues, isolation of bacteria, and the duration of inpatient stay) similarly to physicians or nurses in an outpatient clinic environment. This led the investigators to conclude, incorporation of photograph-based telemedicine into regular practice could reduce unnecessary hospital visits [2]. Another study looked at two groups of vascular postoperative patients who had infrainguinal incisions, one being the TeleHealth Electronic Monitoring (THEM) group and the other being the standard of care group with discharge instructions. The THEM group was provided a tablet for image capture, blood pressure cuffs, thermometers, and an oxygen saturation monitor. They found technical feasibility for wound monitoring of the THEM group and it proved beneficial to those in geographically disparate areas. They also found high patient satisfaction with the program and patient adher-

ence to requirements of THEM [3]. Other investigations have explored a broader use of telemedicine in the vascular population. One review article focused on studies that used telemonitoring and telecoaching in the peripheral artery disease population [4]. They concluded telemedicine can aid in detection of postoperative complications, improved functional capacity, reduce claudication onset time, and improve patient's quality of life. They did recommend future research focusing on proper implementation of telemedicine in peripheral artery disease population, including clinical, feasibility outcomes, effect on staff work-load, and cost-efficiency [4]. An interesting study looked at the effect of telemedicine on patient travel distance and time with indirect effect on improved environmental pollutant emissions [5]. They found average patient round-trip travel distance and time reductions of 31.2 miles and 39 minutes. Because of this, they also calculated a reduction in emissions [5]. These findings provide further positive evidence for telemedicine in the vascular population with indirect environmental impact. Finally, literature review identified two publications specifically discussing use of remote ultrasound diagnostic testing [6,7]. The first study discusses use of point-of-care ultrasound in the geriatric population and was a case series done by a single institution. They found use of in-home point-of-care ultrasound in their patient population resulted in management changes in 64% of patients. Those changes included medication adjustments and deferral of future imaging [6]. These data provide evidence that in-home ultrasound is feasible and has measurable impacts on patient management in a nonvascular population. The second study acted as a pilot study that followed telemedicine visits at outreach clinics with known vascular patients with a wide array of pathologies. Ultrasound was performed on 90.2% of the patients. All patients participated in a questionnaire, with 91% of participants stating they would recommend a virtual physician encounter to a friend. All participants indicated it was more convenient than a traditional office visit, and all felt communication with the physician was good. The pilot study concluded telemedicine



**Table 3 – Number and percentage of responders by quantitative scale.**

Statement	Response, <sup>a</sup> n (%)
1. The scheduling process for the in-home testing was easy and straightforward.	1: 45 (86.5)
	2: 4 (7.7)
	3: 1 (1.9)
	4: 0 (0)
	5: 1 (1.9)
No response: 1 (1.9)	
2. I appreciated the COVID symptom screening being done prior to the scheduled visit and prior to the arrival of the vascular sonographers to my home.	1: 37 (71.2)
	2: 5 (9.6)
	3: 6 (11.5)
	4: 1 (1.9)
	5: 1 (1.9)
No response: 2 (3.8)	
3. I felt safe having the testing performed in my home.	1: 43 (82.7)
	2: 5 (9.6)
	3: 3 (5.8)
	4: 0 (0)
	5: 1 (1.9)
No response: 0 (0)	
4. Having in-home testing during the COVID-19 Pandemic and stay-at-home order made me less worried about my vascular problems.	1: 36 (69.2)
	2: 4 (7.7)
	3: 9 (17.3)
	4: 1 (1.9)
	5: 2 (3.8)
No response: 0 (0)	
5. The process for receiving results was explained and occurred as described.	1: 40 (76.9)
	2: 6 (11.5)
	3: 4 (7.7)
	4: 1 (1.9)
	5: 1 (1.9)
No response: 0 (0)	
6. I would have the in-home testing again if available.	1: 44 (86.4)
	2: 5 (9.6)
	3: 1 (1.9)
	4: 0 (0)
	5: 1 (1.9)
No response: 1 (1.9)	
7. I would recommend having the in-home testing to other patients.	1: 44 (86.4)
	2: 4 (7.7)
	3: 3 (5.8)
	4: 0 (0)
	5: 1 (1.9)
No response: 0 (0)	

Abbreviation: COVID-19, coronavirus disease 2019.

<sup>a</sup> 1 = strongly agree; 2 = agree; 3 = neutral; 4 = disagree; 5 = strongly disagree.

in combination with outreach clinic ultrasound was effective in the evaluation and monitoring of chronic common vascular conditions [7].

Our pilot program proved to be a safe, well-accepted way to provide vascular testing to patients during the COVID-19 pandemic and shelter-in-place orders in our community. Patients felt safe having the sonographers enter their home, were satisfied with the ability to having in-home testing and receive the results within 48 hours and would have in-home testing again if offered. The program provided patients with a sense of relief from the worry of their cancelled appointments

**Table 4 – Vascular management preference if in-home testing unavailable.**

Statement	Response, <sup>a</sup> n (%)
If the in-home testing were not available, which option would you have chosen:	A: 33 (63.5)
	B: 12 (23.1)
	C: 4 (7.7)
	No response: 3 (5.8)
<sup>a</sup> A = drive to the office for testing; B = cancel testing appointment at office and wait until coronavirus disease 2019 epidemic or stay-at-home order was over, C = other.	

and resulted in identification of patients in need of urgent intervention. Four patients were found to have critical findings, two of the four patients required hospitalization. This resulted in graft salvage in at least one of the patients. All critical findings were lower extremity arterial issues, including high-grade stenosis in a bypass graft and in-stent stenosis. Financially, it accounted for nearly one-half of the vascular laboratory volume and billing during the trial period. Although we did not perform a formal survey of our sonographers, the verbal feedback from both was very positive. Neither felt they had any compromise in the ability to perform the studies ordered and at no time felt unsafe from a COVID-19 exposure.

We feel some of the key points for starting a similar program are to have sonographers comfortable and experienced with performing vascular studies using mobile equipment, leadership support for the program in providing access to vehicles and flexibility in scheduling to allow for travel and data entry, as well as appropriate PPE. Both of our sonographers had experience working for a company that performed vascular testing/screening outside a formal vascular laboratory, which made them very comfortable with this program. Our leadership recognized the need to support our patients throughout this program and we were able to divert PPE from our outpatient areas, which were closed due to the pandemic, to the mobile team.

#### 4. Conclusions

We have demonstrated the IHVT program is feasible and even preferred for some patients. We were able to provide much-needed surveillance to our patient population in a time of uncertainty. There is potential for application of our IHVT program in the future for our patients with limited mobility or transportation issues or during future pandemic surges. This program provided some financial support and allowed our sonographers to continue to work within their trained field, despite the significant reduction in patient encounters in our office. We believe other outpatient vascular offices would see similar success with the implementation of a program like the one we have outlined here.

**Table 5 – Financial impact.**

Time period and site	Days of testing, n	Total patients, n	Total tests, n	Gross charges, \$
April 2019 (all sites)	22	986	1,081	486,456
April 2020 (office sites)	22	96	108	44,849
In-home program	22	84	105	42,582

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