Implementation and Impact of a Maternal–Fetal Medicine Telemedicine Program

Cassandra Leighton, MPH[1] Molly Conroy, MD, MPH[2] Andrew Bilderback, MS[3] Wendy Kalocay, MBA[4] James K. Henderson[3] Hyagriv N. Simhan, MD, MS[5]

[1] Health Policy Institute, University of Pittsburgh, Pittsburgh, Pennsylvania
[2] Department of General Internal Medicine, University of Utah School of Medicine, Salt Lake City, Utah
[3] Wolff Center, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania
[4] Women's Telehealth Services, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania
[5] Department of Obstetrics, Gynecology and Reproductive Sciences, University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania

Address for correspondence Cassandra Leighton, MPH, Health Policy Institute, University of Pittsburgh, 3550 Terrace Street, Scaife Hall, Suite S311, Pittsburgh, PA 15261 (e-mail: cal159@pitt.edu).

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Abstract

Objective The increase in maternal morbidity has resulted in higher need for maternal–fetal medicine (MFM) subspecialty care. To meet the rising demand, particularly in rural areas, the use of MFM telemedicine services has increased. This study describes the structure, implementation, and patient and child health outcomes associated with a large health system's MFM telemedicine program.

Study Design Observational electronic health record data are used to compare maternal and childbirth outcomes between patients receiving care via telemedicine or in-person visits through regression analysis. Average patient time and resources saved are calculated, and patient satisfaction scores are reported.

Results The telemedicine patients experienced similar outcomes to the in-person group, indicating that MFM telemedicine can serve as an effective substitute for in-person care. MFM telemedicine patients saved $90.28 per consult in travel and work-related expenses. An overwhelming majority of MFM telemedicine patients were satisfied with their visit and indicated that they would be interested in receiving care via telemedicine in the future.

Conclusion The results indicate that the patients may benefit financially and experience similar outcomes when telemedicine programs are appropriately designed to eliminate access barriers and provide high-quality care.

Keywords
- maternal–fetal medicine
- telemedicine
- maternal
- child
- teleconsult

Nearly 52,000 women experience severe maternal morbidity each year. This number has continued to rise as the rates of obesity, chronic conditions, cesarean deliveries in women of reproductive age increase nationally.[1] Maternal morbidity is associated with greater risk of unexpected medical problems during pregnancy, such as early labor, bleeding, or high blood pressure.[2–4] This has created a greater reliance on maternal–fetal medicine (MFM) subspecialists.

As of 2010, there were 1,355 MFM subspecialists in the United States—equating to one MFM provider for every 3,150 births.[5] Women in more medically dense communities have greater access to MFM services than those in less medically dense communities, and access to MFM care and services becomes less available with increasing rurality.[3,5] It is estimated that 24.5 million women of reproductive age reside in a county that is without a MFM provider.[6] The availability of

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MFM providers is inversely related to poor maternal outcomes and maternal mortality.[6,7] To improve MFM access to women in areas with lower density of medical specialists and increased rurality, health-care professionals have turned to telemedicine, in which expert care is provided through a provider-to-provider or provider-to-patient format.

Much of the research associated with MFM telemedicine programs has been devoted to specific condition management over the course of the pregnancy.[8–14] In general, there are good levels of acceptance of telemedicine interventions and usage among women.[10,15] However, limited information is available on outcomes associated with MFM care delivered via teleconsult centers compared with an in-person visit. The most comprehensive teleconsult evaluation was completed for the Arkansas' ANGELS telemedicine outreach program for high-risk pregnancies, where a consulting MFM specialist saw the patient over technology and permitted the patient to continue to receive care at their local provider.[16] The program resulted in earlier identification of high-risk pregnancies, and researchers concluded that provider decisions to transfer high-risk patients were influenced by the combination of available hospital-level and telemedicine resources.[16–19] The ANGELS program focused on patterns of referral and transfer, which leaves opportunities to explore MFM telemedicine associated birth outcomes and patient cost and time savings.

This study focused on the structure, implementation, and maternal and child health outcomes associated with our health system's MFM telemedicine program from January 1, 2012 to December 31, 2015. There were three primary aims. First, we described the characteristics of the patient population. Next, we compared maternal and child health outcomes between two patient cohorts: MFM care via telemedicine and MFM care via traditional in-person visits. Finally, we calculated the time and resources saved by using a telemedicine approach opposed to a face-to-face visit.

Methods

Setting: UPMC Department of Maternal–Fetal Medicine

The Division of Maternal-Fetal Medicine of Magee-Womens Hospital of University of Pittsburgh Medical Center (UPMC) in Pittsburgh, Pennsylvania, is comprised of 12 physicians and 3 advanced practice providers. The MFM subspecialists offer outpatient consultative services at seven office locations and eight teleconsult centers; the division sees an average of 10,590 consultations and office visits per year. There are seven UPMC facilities in six different counties across the state of Pennsylvania that offer obstetrical services.

The distances of these facilities from Magee-Womens Hospital range from 71 to 160 miles (►**Fig. 1**).

Given the higher rurality in communities surrounding Pittsburgh, our system established an MFM telemedicine program in 2012 with the overall goal of providing MFM specialist care locally and retaining patients at community facilities, while simultaneously increasing access to MFM specialists. Through use of telemedicine consultation (teleconsult) centers, the system sought to limit the number of unnecessary inpatient transfers after delivery and to reduce barriers for seeking traditional MFM specialist care. Unnecessary inpatient transfers are the transfer of patients to higher acuity care settings that are not a direct result of patient complexity, but are determined by a dearth of local physician expertise. By using telemedicine, care team members have increased access to specialty providers and their expertise, which should reduce the need to provide care elsewhere. Additional barriers specifically targeted by the program were travel time and travel-related expenditures.

The MFM telemedicine program was developed to enable patients in rural locations to seek consultation for high-risk pregnancy without the inconvenience, time, and expense associated with traveling to Pittsburgh to see a specialist. Teleconsult centers were established in five rural areas in western Pennsylvania. At the teleconsult centers, patients are evaluated by MFM physicians comprehensively through remote review of medical records and face-to-face consultations using secure video technology. Tele-ultrasound services enhance the MFM telemedicine program by allowing patients to have their obstetrical ultrasounds performed at their local facility. Images from the study are electronically transmitted to Magee in real time and subsequently interpreted by MFM physicians.

This project was approved by the Quality Improvement Review Committee at UPMC.

Telemedicine Visits, Patient Characteristics, and Health Outcomes

Department identification numbers were used to find unique individuals with an MFM consult in the EpicCare outpatient electronic health record (EHR) from January 1, 2012 to December 31, 2015. Appointment type codes distinctly classified initial visits as either done as telemedicine or in-person. We pulled simple demographic information, such as age, race, and insurance type, from the EHR and summarized for both groups. Patients with missing data were removed from the denominator of the appropriate demographic field. From each initial MFM visit, International Classification of Diseases, Ninth Revision (ICD-9) billing and claims diagnoses codes were extracted for comparison.

The outpatient EHR information was supplemented with inpatient claims data. We used the medical record number (MRN), a unique patient identifier linking both the inpatient and outpatient electronic systems, to identify all UPMC inpatient stays. We filtered inpatient stays for global maternity CPT codes. Only women who delivered within the UPMC system were included in the analysis. Using ICD-9 and ICD-10 codes, the frequency of diagnoses at delivery, delivery type, deaths at delivery, premature deliveries (< 37 weeks), and births with a death at delivery were calculated. In addition to information on the mother's delivery and health, we also evaluated child health outcomes. At each birth, a new patient MRN is generated for the child. We reviewed charts for birth weight, length of stay in the nursery, admission to the neonatal intensive care unit (NICU), and NICU length of stay. Individuals were not excluded for missing data.

For those with a telemedicine consultation, we mapped the hospital where the delivery occurred to the location at

which the telemedicine consult occurred. This information illustrated if the individual was able to remain at their local, community hospital for delivery.

Calculation of Patient Time and Resource Saving

As a telemedicine intervention, we wanted to reduce patient barriers to care. We focused on patient travel costs related to gas expenditure and work time lost. We chose to look at all completed consults at each of the locations. Due to discrepancies in the Bedford volume, we only included the five visits identified in the telemedicine visits, patient characteristics, and health outcomes component of the study. This provides a more conservative estimate and is reflected in the count of 998 completed consults.

To calculate patient cost savings, we used MapQuest to identify mileage and travel time for the shortest route from Magee-Womens to each of the teleconsult centers. Next, we determined the annual average cost of a gallon of gas and hourly rate for an hour worked from national data provided by U.S. Office of Energy Efficiency & Renewable Energy and St. Louis Federal Reserve Bank, respectively. We adjusted gas costs to reflect the national average fuel efficiency in 2013 (23.6 miles per gallon). National hourly rate data were provided for each month and we chose to use the mid-point of each year (June) as the average rate in the calculations.

Patient Satisfaction

To measure patient satisfaction, the telemedicine team adapted validated Press-Ganey measures to include language specific to the telemedicine consultation. The telemedicine component was a series of 11 questions in multiple choice or 5-point Likert scale format. These questions included items on interactions with the telemedicine team, comparisons to an in-person visit, and perceptions of telemedicine benefits. The telemedicine benefits section asked about travel time, inclusion of family members, and future interest in telemedicine services. After each visit, the patient would complete a satisfaction survey at the teleconsult center via an electronic survey on an iPad.

Since collection of telemedicine patient satisfaction surveys began January 1, 2014, results are for only a segment of the study timeframe. Additionally, because of the methodology in which the responses were recorded, it was impossible to ensure that there was only one response per patient. A patient with multiple MFM telemedicine consults could have completed the survey at the end of each visit. All responses are included in this analysis. The survey items can be found in (►**Table 5**).

Statistical Analyses

We analyzed differences between telemedicine consultation and in-person patient groups using chi-square tests for categorical data and unpaired *t*-tests for continuous data. A *p*-value of less than 0.05 was considered a significant difference. We used a simple logistic regression to calculate odds ratios for main clinical outcomes of interest (i.e., cesarean, prematurity, underweight newborn, large for gestational age newborn, NICU stay) with telemedicine use as the primary predictor of interest. We then calculated adjusted odds ratios for the same outcomes by using a logistic regression model controlling for age, race, insurance type, and past medical/pregnancy history. Variables included in past medical/pregnancy history were diabetes, hypertension, preterm labor, cesarean history, twin gestation, and pre-eclampsia history. We used Stata 13.1 for all analyses.

Results

Outcomes

Between January 1, 2012 and December 31, 2015, we identified 6,757 unique individuals with an MFM visit and 998 completed MFM teleconsults at five centers. Each individual was classified into an MFM group based upon the category of their initial visit, resulting in 6,302 unique individuals with an in-person MFM consult and 455 with a telemedicine consultation (►**Table 1**). On average, the women who had a telemedicine consult were younger, more likely to identify race as Caucasian, and more likely to have public insurance than women who had an in-person MFM consult (all $p < 0.001$). The most common conditions listed during a telemedicine consultation included diagnoses of diabetes, history of preterm labor, hypertension, and pre-eclampsia. There were some differences in frequencies of these diagnoses between groups, with lower rates of disease among the telemedicine consultation group.

Cesarean rates were above 40% and fetal death occurred in 2% of cases in both groups. There was no significant difference between groups (►**Table 1**). Women who had a telemedicine consultation had lower rates of premature delivery ($p = 0.022$) and lower rates of NICU use ($p < 0.001$) than women with an in-person consult; accordingly, the length of NICU stay was shorter in the telemedicine consultation group compared with the in-person group ($p < 0.001$). Overall, birth weight and frequency of underweight infants did not differ between groups. However, women with a telemedicine consultation were less likely to have an infant with macrosomia than women in the in-person group ($p = 0.016$).

From the adjusted logistic regression model (►**Table 2**), we determined that women in the telemedicine consultation group had 0.65 times as likely to have a NICU stay for their baby ($p = 0.02$) and 0.20 times as likely to have babies with NICU stays longer than 1 day ($p < 0.001$) as the women receiving in-person MFM services. There were no differences between odds in any of the other clinical outcomes. This corresponds to the initial differences seen between groups in the descriptive analysis.

The women receiving telemedicine consultations delivered their baby at that same location in 84.4% of the instances (►**Table 3**). Two telemedicine consultation centers had women deliver elsewhere: UPMC Horizon and UPMC Northwest. Horizon had 25 women (18.3%) deliver their baby in another location, and Northwest had 46 women (15.2%). Of these 71 deliveries, 70 took place at a level 3 facility (Magee and Hamot), a more acute care setting than where these women first received their MFM care.

Table 1 MFM telemedicine consults compared with MFM in-person consults

Characteristics ($n = 6757$)	**MFM in-person consult ($n = 6302$)**	**MFM telemedicine consult ($n = 455$)**	***p*-Value**
Age of mother, mean (SD)	30.7 (5.5)	28.6 (5.4)	< 0.001
Caucasian, *n* (%) ($n = 6,480$)	5,010 (83)	438 (96)	< 0.001
Public insurance, *n* (%) ($n = 5,974$)	2,129 (37)	111 (56)	< 0.001
Diagnoses at MFM consult(s) ($n = 6,378$), *n* (%)			
Diabetes	2,055 (35)	123 (27)	0.001
History of preterm labor	751 (13)	23 (5)	< 0.001
Hypertension	634 (11)	31 (7)	0.006
Previous cesarean	615 (10)	32 (7)	0.017
Twin gestation	369 (6)	22 (5)	0.356
History of pre-eclampsia	459 (8)	61 (13)	< 0.001
Diagnoses at delivery, *n* (%)			
Outcome of delivery, single liveborn	5,761 (91)	417 (92)	0.863
Diabetes	2,038 (32)	126 (28)	0.038
Hypertension	643 (11)	47 (10)	0.739
Pre-eclampsia	515 (8)	34 (7)	0.594
Carrier or suspected carrier of Group B streptococcus	1,389 (22)	78 (17)	0.012
Perineal laceration	2,410 (38)	147 (32)	0.011
Previous cesarean delivery	1,273 (20)	112 (25)	0.027
Abnormality in fetal heart rate or rhythm	982 (16)	76 (17)	0.529
Elderly multigravida	893 (14)	49 (11)	0.037
Mental disorders of mother	799 (13)	66 (15)	0.268
Delivery type ($n = 6,721$)			
Cesarean, *n* (%)	2,585 (41)	196 (43)	0.354
Vaginal, *n* (%)	3,685 (59)	255 (57)	
Premature (< 37 weeks), *n* (%) ($n = 6,588$)	1,342 (22)	73 (17)	0.022
Births with a death at delivery, *n* (%)	135 (2)	9 (2)	0.813
Baby-specific measures (includes twins and multiples) ($n = 7,045$)	**MFM in-person consult ($n = 6,571$)**	**MFM telemedicine consult ($n = 474$)**	
Birthweight ($n = 7,003$), mean (SD)	3,023 (810)	2993 (732)	0.422
Underweight (birthweight $< 2,500$ g), *n* (%) ($n = 7,003$)	1,353 (21)	91 (19)	0.467
Macrosomia (weight $\geq 4,000$ g), *n* (%) ($n = 7,003$)	506 (8)	23 (5)	0.016
Nursery LOS in days, mean (SD) ($n = 7,042$)	6.0 (12.1)	4.6 (9.6)	0.014
NICU, *n* (%) ($n = 7,005$)	1,960 (30)	89 (19)	< 0.001
NICU LOS ≥ 1 day, *n* (%) ($n = 6,548$)	1,462 (24)	48 (10)	< 0.001

Abbreviations: LOS, length of stay; MFM, maternal–fetal medicine; NICU, neonatal intensive care unit; SD, standard deviation.

Patient Cost Savings

The average national gas prices declined from \$3.64/gallon to \$2.45/gallon between 2012 and 2015. During that same time, the average hourly pay rate increased from \$19.72 to \$21.00. Using these values to calculate patient cost savings, we determined a total of \$90,103.90 saved from reductions in gas expenditures and lost work time for 998 completed teleconsults (►**Table 4**). This equates to a saving of \$90.28 per completed consult.

Satisfaction Data

In 2014 and 2015, there were a total of 539 completed telemedicine consultations and 465 completed patient satisfaction surveys. The patient satisfaction survey response rate

Table 2 ORs for selected clinical outcomes

Clinical outcome	OR[a]	*p*-Value	aOR[b]	*p*-Value
Cesarean	1.10 (0.90, 1.33)	0.35	1.10 (0.80, 1.52)	0.55
Premature	0.74 (0.57, 0.97)	0.03	0.72 (0.48, 1.10)	0.13
Underweight	0.89 (0.70, 1.13)	0.35	0.71 (0.46, 1.11)	0.46
Large for gestational age	0.61 (0.40, 0.94)	0.03	0.98 (0.56, 1.69)	0.93
NICU stay	0.54 (0.43, 0.68)	< 0.001	0.65 (0.46, 0.93)	0.02
NICU stay $>$ 1 day[c]	0.32 (0.21, 0.49)	< 0.001	0.20 (0.11, 0.38)	< 0.001

Abbreviations: MFM, maternal–fetal medicine; NICU, neonatal intensive care unit; aOR, adjusted odds ratio.
[a]ORs are for women receiving telemedicine MFM services compared with a reference group of women receiving in-person MFM services.
[b]Models are adjusted for age, race, insurance type, and past medical/pregnancy history (i.e., diabetes, hypertension, preterm labor, cesarean history, twin gestation, and pre-eclampsia history).
[c]Among infants with NICU stay ($n = 1598$).

Table 3 Telemedicine consult location by hospital where delivery occurred ($n = 455$)

	Telemedicine consult location					
Hospital where delivery occurred	**Altoona**	**Bedford**	**Hamot**	**Horizon**	**Northwest**	**Total**
Altoona	6 (100%)					6
Bedford		5 (100%)				5
Hamot			4 (100%)	1 (0%)		5
Horizon				112 (82%)		112
Magee				23 (17%)	46 (15%)	69
Northwest				1 (0%)	257 (85%)	258
Total	6	5	4	137	303	455

was 86.3%. Overall, there were high-levels of satisfaction, with 80% indicating that they were very satisfied with the telemedicine visit and 83% saying that they had strong confidence in the physician's telemedicine care. When comparing the telemedicine visit to an in-person visit, 75% rated the telemedicine visit as very good.

Over half (56%) of patients reported that having a telemedicine visit as opposed to an in-person visit saved over 2 hours in round-trip driving time. Additionally, 74% reported that the telemedicine visit allowed a family member to be present who would not have been otherwise able to attend the appointment. A small but important proportion of patients (11%) reported that without the telemedicine consultation center they would have forgone MFM care. The overwhelming majority of respondents (95%) indicated that they would be interested in participating in future telemedicine visits (►**Table 5**).

Discussion

The MFM telemedicine program strived to reduce these issues by providing an equivalently effective substitute to specialized MFM face-to-face care. Our results indicate that there were no negative impacts in the use of a telemedicine MFM consultation as compared with an in-person visit. In fact, the use of the NICU and length of stay when a NICU admission occurred were lower in the telemedicine group than the in-person group.

Patients also benefitted by being able to receive MFM subspecialty care at their local hospital. There were two main benefits. First, the patients experienced cost savings. The MFM telemedicine consultation patients saved an average of $90.28 per visit, which includes gas and travel time expenditures. Next, it created an extension of the MFM care network into underserved communities, allowing women to remain at their usual place of care over the course of their pregnancy. It is possible that personal relationships were able to grow as the teleconsult center's team learned about the mother's history and complications during pregnancy, worked with the MFM providers to deliver care, and prepared for the mother's delivery. The high number of deliveries that occurred at each patient's respective teleconsult center are potentially indicative of that established trust and comfort. Additionally, 98.59% of the women who delivered at another location moved to a facility with a greater acuity NICU level. This pattern could reflect proactive care planning and referral to appropriate level of care based upon complexity and risk.

A predominately white, publicly insured population used the MFM telemedicine program. Given Pennsylvania's rural demographic profile, this appears to be representative. Only 8% of the rural Pennsylvania population are minorities, and

Table 4 Patient cost savings for completed consults by location ($)

Teleconsult location	Distance (miles)	Travel time (mins)	2012 Gas costs saved	2012 Work costs saved	2012 Annual cost savings total	2013 Gas costs saved	2013 Work costs saved	2013 Annual cost savings total	2014 Gas costs saved	2014 Work costs saved	2014 Annual cost savings total	2015 Gas costs saved	2015 Work costs saved	2015 Annual cost savings total	2012–2015 Site cost savings
Average national cost of gallon of gas[a]			3.64			3.53			3.37			2.45			
Average national hourly rate[b]			19.72			20.12			20.59			21.00			
Altoona	95.5	114	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	456.05	1835.40	2291.45	2291.45
Bedford	110	106	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	114.19	371.00	485.19	485.19
Hamot	130	129	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	431.86	1444.80	1876.66	1876.66
Horizon	72.3	78	0.00	0.00	0.00	0.00	0.00	0.00	1156.31	2997.90	4154.21	2897.21	10537.80	13435.01	17589.22
Northwest	95.8	105	561.49	1311.38	1872.87	9084.18	3696.99	12781.17	5389.89	14196.81	19586.69	7160.64	26460.00	33620.64	67861.37
Total cost savings:															**$ 90,103.90**

[a]Annual gas prices provided by the U.S. Office of Energy Efficiency & Renewable Energy.
[b]Annual hourly rates provided by the St. Louis Federal Reserve Bank.

Table 5 Patient satisfaction survey results ($n = 539$)

Survey item	*n* (%)
The presence of nurse/physician in the room helps you with your telemedicine visit	401 (86)
How well were you able to establish a personal connection to the specialist during the telemedicine visits, compared with in-person doctor visits?	336 (72)
Your confidence in this physician's telemedicine care (5 = very good)	387 (83)
Likelihood of your recommending this physician to others (5 = very good)	375 (81)
Compared with seeing a physician in person, how would you rate this telemedicine visit? (5= very good)	347 (75)
Likelihood of your recommending telemedicine to others (5 = very good)	365 (78)
How much driving time did this telemedicine consult save (roundtrip)?	
0–2 hours	193 (42)
2–4 hours	156 (34)
4–6 hours	91 (20)
>6 hours	11 (2)
Did telemedicine allow family members to be present who would otherwise not have been able to attend the visit?	346 (74)
(Would have forgone care if telemedicine wasn't available)	52 (11)
Would you be interested in participating in future telemedicine visits?	444 (95)
How satisfied were you with the telemedicine visit overall?	370 (80)

there is a high reliance on Medicaid.[20] Nearly 22% of individuals under the age 65 were receiving Medicaid benefits as of 2015.[20,21] Rates of Medicaid are even higher in pregnant women. Despite having a slightly better clinical profile, the high rate of public insurance in the telemedicine consultation group indicates some level of vulnerability. Due to lower rates of reimbursement, provider access among Medicaid beneficiaries can be difficult. Access issues are further compounded in this population by distance from higher acuity neonatal care and the difficulty of attracting and retaining providers in rural areas.

Our results are comparable to other MFM telemedicine program evaluations. The patient satisfaction was high, and we can conclude that the UPMC MFM telemedicine program is an effective and appropriate substitute for face-to-face MFM visits in underserved areas. Just as the Arkansas' ANGELS researchers found that provider decisions to transfer were influenced by the availability of telemedicine, we believe that provider and patient decisions to deliver at their local facility were influenced using the teleconsult centers over the pregnancy. This results in greater volumes at community hospitals, appropriate escalations of acute care at delivery, and

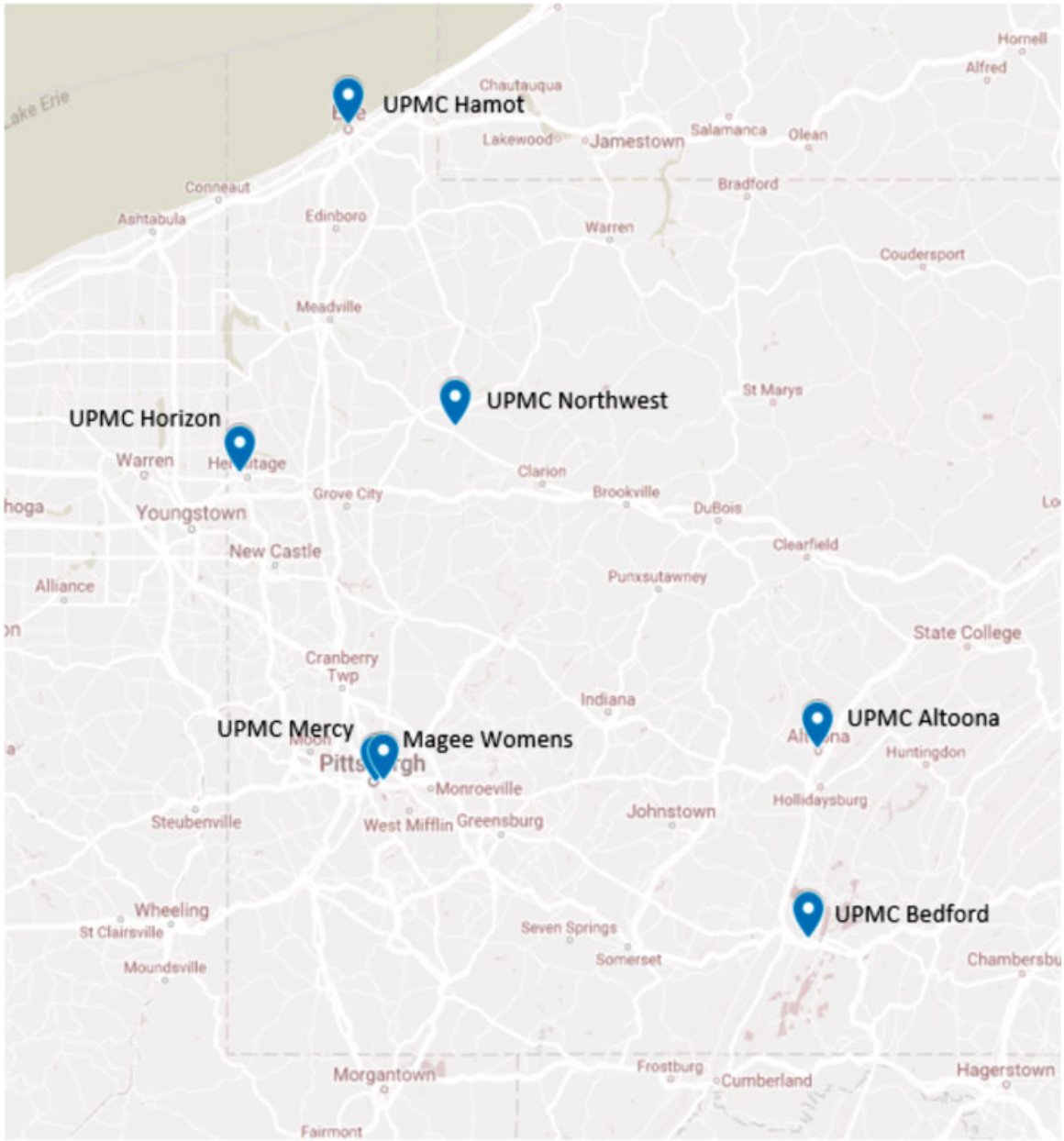

Fig. 1 Teleconsult locations.

reductions in travel time and costs—all which contribute to cost-savings for the health-care system and patient.

The encouraging results of this study indicate that teleconsult centers can be used to expand access to subspecialty care. In doing so, true system-level benefits can be derived. We plan to conduct future research to evaluate the use of telemedicine consultations in other clinical specialties and to expand the current MFM model to include more routine prenatal visits. There is also opportunity to explore the impact of MFM telemedicine consultation by disease cohort.

Limitations

There are several limitations to our methods. First, this study was conducted in just one health system, which limits generalizability. Second, the number of patients using the MFM telemedicine consultations over the 4 years was relatively low. We were limited to 4 years of databased upon the time restrictions of the quality improvement project. Also, there was no true control group identified a priori or matched to the MFM telemedicine consultation group on underlying characteristics. We compared the observational cohorts on a few characteristics that we could abstract from the EHR, leaving the potential for unmeasured confounding factors.

Finally, we encountered issues with the patient satisfaction data. As mentioned previously, we only had patient satisfaction data for a portion of the study period. Second, it was impossible to ensure that the respondents were the same patients who subsequently gave birth within the system. When using the data itself, we witnessed a ceiling effect among responses—with high level of acceptance and satisfaction with care across all sites.

Conclusion

Our study demonstrates that an MFM telemedicine consultation center can be used to increase access to effective subspecialty care for high-risk pregnant women. As healthcare systems aim to improve population health, it is necessary to innovate and to modify provider and patient care patterns and behaviors. This intervention builds local hospitals' capacity to treat and care for those patients most at risk of complications. It also has the potential to increase or maintain patient volume at lower acuity facilities. Our results indicate that the patients may benefit financially and experience similar outcomes when telemedicine programs are appropriately designed to eliminate access barriers and provide high-quality care.

Conflict of Interest
None.

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