NEJM Catalyst | Innovations in Care Delivery

CASE STUDY

Developing and Scaling Remote Patient Monitoring Capacity in Ambulatory Practice

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Vol. 5 No. 6 | June 2024

DOI: 10.1056/CAT.23.0417

Although remote patient monitoring (RPM) has been shown to improve health outcomes and increase patient engagement with care, its real-world uptake has been limited by technical constraints, resource limitations, and limited reimbursement. NYU Langone Health (NYULH) has a growing ambulatory RPM program across a diverse network, with more than 8,000 patients enrolled in home-based monitoring of at least one physiologic parameter since program inception. In this case study, the authors share NYULH's 6-year experience building RPM capacity within the health system, with a focus on improved clinical outcomes, operational sustainability, and equity. These RPM efforts differ from those of other health systems in that the focus is on building tools and workflows for practices that are interested in using RPM rather than on building centralized RPM programs for specific high-need populations. Key features of the program include support for a variety of data (blood pressure, glucose, heart rate, temperature, oxygen saturation, forced expiratory volume in 1 second, weight, and steps); a practice-level implementation strategy tailorable to the needs of diverse practice settings; and data review and escalation protocols that empower nurses, pharmacists, and advanced practice providers to manage RPM data. Exploratory features include a playbook detailing best practices for RPM use across NYULH, a device loaner program, direct Bluetooth pairing (as opposed to Bluetooth syncing and transmission of data through data aggregator pathways), systematic offboarding workflows for inactive or stable patients, and small centralized programs being developed among groups of practices with similar patient populations and needs (e.g., primary care faculty group practices managing hypertension). These exploratory

features have resulted in improvements to the program, including a 58.7% increase (from 252 of 841 [30.0%] between January 2018 and March 2020 to 1,617 of 3,394 [47.6%] between July 2022 and June 2023) in uptake (i.e., patients submitting at least one data point at any time after receiving an RPM order), a 10.4% increase (from 4.8 between January 2018 and June 2022 to 5.3 between July 2022 and June 2023) in the amount of data submitted per patient per week, and a 532.5% increase (from 8.0% to 50.6%, before February 2023 and after February 2023) in resolved RPM episodes (i.e., inactive and clinically normal and stable patients offboarded from the program). The authors believe the infrastructure and processes presented here can be utilized in other health systems interested in a flexible and scalable approach to enterprise-level ambulatory RPM capacity.

KEY TAKEAWAYS

- Recognize that ongoing remote patient monitoring (RPM) challenges related to patient engagement, staffing demands, and reimbursement potential call for continuous improvement efforts.
- Invest in direct Bluetooth syncing and loaner programs to increase uptake and mitigate inequities.
- Account for reimbursement or related financial sustainability considerations early in implementation.
- Engage RPM-related vendors frequently with a flexible outlook to shape their product offerings and continuously improve your RPM program.
- Design user-friendly RPM management interfaces to ensure that patients do not slip through the cracks and to reduce provider cognitive burden when reviewing values.
- Work with practices to tailor RPM workflows on the basis of resource constraints.
- Facilitate partnerships between groups of similar practices (patient populations or indications for RPM) that could team up to centralize their RPM programs.
- Systematically offboard both inactive and stable patients to optimize resource allocation and facilitate interpretable metrics for strategic improvements.
- Maintain a playbook of RPM best practices to scale improvements across the health system.

The Challenge

Remote patient monitoring (RPM) has been shown to improve control of conditions including hypertension,[1-3] diabetes,[4] and sleep apnea.[5] Beyond improving metrics, such as blood pressure (BP) and glucose, RPM decreases hospitalizations,[6,7] reduces costs,[6,7] and increases engagement with care.[8-10] Despite demonstrated efficacy and recent guideline recommendations to use RPM,[11] it has not been widely adopted in practice.[12,13] Most RPM billing in the United States has been found to be driven by a small number of primary care providers.[12] Meanwhile, health systems implementing RPM have struggled to operationalize financially sustainable, equitable, and scalable programs.

In clinical practice, various constraints make it challenging to implement the best practices discovered in RPM trials. RPM studies have shown mixed results that are heavily dependent on the level of proactivity and response techniques used when managing incoming values.[14,15] In clinical practice, lack of grant funding leads to reliance on sufficient reimbursement to fund devices and provider time, limiting the ability to rigorously operationalize the high-touch, highly standardized RPM workflows that are most successful in trial settings. Additionally, trials have rigorous inclusion and exclusion criteria that can make it difficult to generalize successful implementation of RPM in a study to diverse populations. NYU Langone Health (NYULH) sought to design an RPM program that addressed these barriers while realizing the accompanying benefits to care delivery and patient outcomes.

The Goal

The NYULH system is a large urban academic medical center with 15,000 clinicians, 9.3 million patients, and 400 locations in New York and Florida. Ambulatory patients are seen at faculty practices, community-based practices, federally qualified health centers (FQHCs), and ambulatory surgery and rehabilitation centers. The patient population is diverse with respect to race and ethnicity, language, socioeconomic status, and other demographics. There is a mix of payers, including NYULH FQHCs (Medicaid funded) and a small proportion of patients being covered through value-based contracts.

NYULH's RPM program launched in 2017 after learning about RPM as a new feature in Epic; clinicians expressed interest and started to experiment, and leadership realized that RPM will be an important part of the future of health care and wanted to learn how to do it well early. The program is part of a broader digital transformation effort and aims to support better health management by empowering patients to engage with their health data and receive personalized ambulatory care. To achieve this vision, the RPM operational team synthesized feedback from relevant stakeholders within the health system to establish the following goals and corresponding metrics.

> *"The remote patient monitoring program uses human-centered design and principles of agile software development to be tested, deployed, and refined over multiple release cycles."*

Improved clinical outcomes: RPM improves how patients use connected devices at home to manage their health (condition) for the betterment of their health. Metrics include changes in physiologic parameters from the initiation of RPM to an appropriate time period after (e.g., for BP for primary care, change in BP from initiation of RPM to 3 months after), the percentage of patients at the goal for that physiologic parameter after an appropriate time period (e.g., percentage of primary care patients with BP less than 130/80 after 3 months in the program), time (in weeks) required to get to the goal parameter, and health care utilization metrics (number of hospitalizations and ED visits pre-RPM/post-RPM).

Operationally sustainable: Eligible patients are identified and enrolled without significantly disrupting practice workflows; inclusion/exclusion is at the provider's discretion (unless established in a clinical trial). Data volume, integration, and visualization are optimized to support clinicians' decision-making. Reimbursement appropriately compensates for RPM work. Metrics include the number of RPM episodes; the number of specialties and providers placing orders; the number of patients submitting at least one data point at any time after receiving an RPM order (uptake); the time from RPM order placement to initial value transmission (activation time); the number of data points submitted per week (engagement); the number of data points submitted per week divided by the number of data points expected per week (adherence); time in the RPM program; the number of patients meeting criteria for each of the RPM U.S. Centers for Medicare & Medicaid Services (CMS) Current Procedural Terminology (CPT) codes divided by the number of patients actively submitting RPM data; the total cost of running the RPM program (incorporating full-time equivalents and other factors); the total amount billed using RPM CMS CPT codes; and the total amount collected from RPM CMS CPT codes.

Accessible and equitable: RPM is equitably distributed among patients. The patient digital experience addresses digital health equity barriers to access and use, including language, trust, and digital literacy.[16] Metrics include the percentage of patients transmitting values automatically, the number of languages the program is offered in, and comparisons of all metrics above across race and ethnicity, gender, age, primary language spoken, insurance type, zip code, and broadband access.

The Execution

Rather than deploying RPM through a centralized condition-specific management approach, the NYULH program emphasizes (1) capacity building across multiple physiologic parameters; (2) a decentralized model in which each practice (or increasingly, each group of practices) manages their own RPM patients; and (3) deep integration with the health system's digital health ecosystem, including the electronic health record (EHR; Epic) and patient portal (MyChart). The program supports BP, glucose, heart rate, temperature, oxygen saturation, forced expiratory volume in 1 second, weight, and steps monitoring.

At the heart of the program lies the NYULH mobile application, which builds upon core Epic infrastructure to transmit data from a Bluetooth-connected RPM device to MyChart. It is then viewable in Epic, where clinicians can track trends over time and engage with patients through patient portal messaging and phone calls. Additional features are deployed using Epic's Care Companion module, which provides patient educational materials, reminders, and escalation questionnaires and instructions when parameters cross thresholds.

The RPM program uses human-centered design and principles of agile software development to be tested, deployed, and refined over multiple release cycles. Multiple iterations of the program have been released, as described in Table 1 and below.

In Phase 0, which occurred between January 2018 and March 2020, we performed a baseline evaluation of NYULH RPM innovators (i.e., individual clinicians who or practices that had implemented small-scale RPM pilots through grants or quality improvement initiatives).[19] This revealed key use cases, requirements, and obstacles for foundational RPM in our system. We also assessed the needs of primary care providers and specialists who expressed interest in RPM, working with them to plan systemwide RPM deployment and strategies. Insights from Phase 0 highlighted the need for a flexible system-level operational plan to strategically and systematically implement RPM. Although most health systems that we had read about and met with had built centralized RPM programs for high-risk conditions (e.g., heart failure), our interviews emphasized the importance of building RPM tools and workflows that could be adapted to different physiologic parameters and to the needs of different practices. Building systemwide RPM capacity was slower, required more research, and took more investment than building centralized condition-specific programs, but it proved to be more future proof. Moreover, the limited reimbursement potential from RPM in our primarily fee-for-service system made large, centralized programs a financially unsustainable approach given the limited reimbursement available for current CMS billing codes for RPM.

> *"Although most health systems that we had read about and met with had built centralized remote patient monitoring programs for high-risk conditions (e.g., heart failure), our interviews emphasized the importance of building remote patient monitoring tools and workflows that could be adapted to different physiologic parameters and to the needs of different practices."*

In Phase 1 (April 2020 to June 2022), we focused on two use cases: the Maternal Fetal Medicine (MFM) practice at NYU Long Island, which was interested in using RPM for gestational diabetes and postpartum hypertension, and the FQHC primary care network, which was starting a grant-funded hypertension control initiative. MFM was particularly involved in this initial phase because of a physician informaticist champion who was very involved in optimizing workflows and a highly motivated population of patients. Core features of this phase included working with these practices to cocreate and iterate a basic workflow (Figure 1) and developing training resources for a small number of other interested practices to begin RPM programs.

Table 1. Summary of NYULH's Remote Patient Monitoring Journey over 6 Years

Key Clinical Sites	Challenges	Approaches/Solutions	Insights/Next Steps
Phase 0: Establishing Needs and Learning from Innovators (January 2018 to March 2020)			
Innovators: • Pediatric Diabetes Center • NYU Long Island Maternal Fetal Medicine Associates • Bariatric Surgery Associates • Lung transplant Prospective Users: • FQHC Primary Care • FGP Primary Care • Cardiology • Ophthalmology • Neurosurgery	Limited understanding of institutional needs for RPM	• Mixed-methods needs assessment at NYU Langone FQHCs and early adopter clinical sites • Spoke to other health systems that had implemented RPM to learn from their experiences	• NYULH should invest in building systemwide RPM capacity rather than building individual condition-specific management programs • Establishing a standardized rollout and operational plan is vital to strategically implement RPM across the health system
	Practice- and provider-level factors (e.g., staffing needs, administrative concerns)	Readiness evaluations for practices (survey)	
	Technical constraints (e.g., data integration, device options, usability)	Meetings with vendors, implementation strategies development	
	Patient-level factors (e.g., device costs, language congruence, digital health literacy)	Engagement with patient stakeholders	
Phase 1: Cocreation of Standard Tools and Workflows with Highly Motivated Early Adopters (April 2020 to June 2022)			
NYU Langone Long Island Maternal Fetal Medicine Associates FQHC Primary Care	Nonstandardized RPM use across the institution	Protocol development on the basis of parallel use cases, worked closely with Epic as central platform for RPM solutions	• Standard operational protocols/high-level workflow developed as a template for other interested practices • Early evidence of improved clinical outcomes[17,18]
	Lack of patient guidelines on device syncing, passive data transmission, and monitoring	Assignment of digital Care Companion tool to RPM orders with tailored reminders	
	Limited patient communication and feedback regarding RPM data	Developed escalation pathways in response to RPM data and refined workflow around clinical interpretation and patient communication	
	No technical support for patients (onboarding, setup, ad hoc support from clinicians)	NYULH's Epic help desk staff were provided with tip sheets for RPM device syncing, and patients could call them for help	

Table 1. Summary of NYULH's Remote Patient Monitoring Journey over 6 Years (cont.)

Key Clinical Sites	Challenges	Approaches/Solutions	Insights/Next Steps
Phase 2: Initial Scaling and Optimization of the RPM Program (July 2022 to June 2023)			
All RPM Practices: Phases 0 and 1 Practices and • FGP Primary Care • NYU Langone Cardiology Associates • Pediatric Diabetes • Weight Management Clinic • Rehabilitation • Other Small Practices	Growing list of practices and reported challenges with RPM	• Current state assessment through semistructured interviews, practice observations, and review of program metrics • Problems prioritized using innovation sweet spot criteria of desirability, viability, integrity, feasibility • Spoke to other health systems and vendors about their approach to these issues	• Providing devices to patients through a practice-level loaner program is a feasible, sustainable way to increase program uptake • More work is needed to further optimize clinical workflow and patient experience and to prioritize equity initiatives • Groups of practices that experimented with teaming up and creating a central program for patients with similar needs and backgrounds (e.g., primary care FQHCs managing hypertension) tended to do better than individual practices managing RPM (e.g., individual primary care FGPs managing patients with hypertension) • A dynamic RPM playbook is useful for scaling changes across the health system
	Limited patient uptake (a majority of patients with RPM orders never submitted even one data point)	Designed and piloted a loaner device program	
	Challenging device syncing process requiring patients to sync their device to the third-party app it was associated with, then to Apple Health or Google Fit, and then to the EHR patient portal app — 70 clicks in total; patients often are unable to navigate the process alone, too complex to allow for effective over-the-phone help from EHR help desk staff	• Worked with vendor (Validic) to implement direct Bluetooth pairing (only 10 clicks now required to sync device) • Continued to support all Bluetooth-connected devices through standard pathway but encouraged providers to recommend Bluetooth devices compatible with Validic	
	• Challenging EHR management through the following: • EHR In Basket workflow that only captured patients who were actively transmitting data • All RPM values delivered to In Basket, resulting in a sense of being overwhelmed by constantly being delivered large amounts of undifferentiated data	• Created a new population-level RPM report allowing for scheduled, systematic review of patient engagement, RPM data, and built-in tools for outreach and documentation • EHR In Basket workflow only used for values surpassing provider-set notification thresholds	
	Large numbers of inactive or stable patients in pool	Established recommended clinical and automatic systemwide offboarding workflows	
	Variable number and licensure of staff members in different practices	Developed practice-level workflow worksheet and worked with each practice to tailor workflows to their needs	

Table 1. Summary of NYULH's Remote Patient Monitoring Journey over 6 Years (cont.)

Key Clinical Sites	Challenges	Approaches/Solutions	Insights/Next Steps
	Underdeveloped and scattered training resources	Created comprehensive internal "playbook" with RPM best practices in one place	
	Difficulty tracking RPM metrics because of data structure within Epic	Invested significantly in increased reporting resources (reassigned staff) toward creating more detailed RPM operational reports, generated 2 new reports	
Phase 3: Current Hurdles Being Tackled (July 2023 to Present)*			
All RPM Practices (listed in Phase 2 above)	Continued difficulty with patient engagement	Exploration of use of generative AI-powered RPM digital assistant to provide more frequent feedback about values and nudge inactive patients to submit values	In progress
	Technical challenges with direct Bluetooth pairing occasionally leads to syncing delays	Continued work with current vendor (Validic) to address these issues; periodic meetings with cellular vendors to monitor market prices	
	Difficult to identify patients who would benefit the most from RPM (in terms of both diagnoses and patient characteristics, such as likelihood to engage with the program)	Additional research planned to answer this question once more data are gathered	
	Providers struggle to answer questions about insurance coverage given the fragmented nature of insurance coverage information	Reviewing practice billing reports to better understand current insurance coverage landscape	
	Providers struggle to find time to manage RPM in practices that treat RPM as a downtime task	Exploring centralization of RPM programs among groups of practices with similar patient populations and needs (e.g., primary care FGPs managing hypertension)	
	Despite intentionally selecting diverse populations to pilot with (including FQHCs), equity challenges persist	• Expansion of Care Companion features and languages • Systemwide efforts to collect more structured social determinants of health data and analyze them for the RPM program	

Table 1. Summary of NYULH's Remote Patient Monitoring Journey over 6 Years (cont.)

Key Clinical Sites	Challenges	Approaches/Solutions	Insights/Next Steps
	Business model for RPM not yet sustainable	• Continue to increase patient engagement and streamline clinician data review and documentation workflows to meet reimbursement criteria • Characterize differences in reimbursement among individual practices doing RPM vs. groups of practices exploring centralized RPM programs • Working with cost-effectiveness analysis experts to do a thorough ROI analysis and better understand other opportunities for improvement	

FQHC = federally qualified health center, RPM = remote patient monitoring, NYULH = NYU Langone Health, FGP = faculty group practice, EHR = electronic health record. *Phase 3 was ongoing as of March 2024; Phase 4 is anticipated to start around March 2025 and to include expansion to widespread enterprise-level deployment. We anticipate 3 years in Phase 5, which would be a sustainable, enterprise RPM across multiple conditions. Source: The authors

FIGURE 1

Basic High-Level Workflow for Remote Patient Monitoring (RPM)

Physicians and advanced practice providers (APPs) placed orders for monitoring their parameter of choice (e.g., blood pressure) through Epic, specifying order parameters as appropriate for that patient. Patients acquired a Bluetooth-connected device that could measure the parameter prescribed and synced the device to Epic using the instructions provided in Care Companion, a patient portal tool; values were then transmitted automatically as they were taken. Nurses, pharmacists, or APPs reviewed values exceeding prespecified order thresholds immediately and reviewed all other values at least weekly, escalating to physicians when necessary and communicating with patients to help manage their health and offboard them from the program when deemed appropriate.

Basic High-Level Workflow for Remote Patient Monitoring

Program Onboarding	Device Acquisition & Setup	Data Submission & Monitoring	Billing	Program Offboarding
Physician or APP Discusses RPM program with patient and places order.		Responds to escalations. Titrates medications to get patient to goal.	Charges automatically entered at the end of each month based on total time for RPM encounters.	Provider can choose to resolve the flow sheet episode and stop receiving patient values.
RN or RPh		Monitors patient values. Escalates to physician or APP as necessary. Documents, logs time.		
Patient Receives enrollment notification for Care Companion.	Acquires devices and connects them to MyChart.	Syncs/enters data according to assigned Care Companion tasks.		Notified by provider that they no longer need to submit RPM values.

RN = registered nurse, RPh = registered pharmacist.
Source: The authors

In the basic workflow, physicians and advanced practice providers (APPs) selected patients who they believed would benefit from RPM to better manage their health and placed orders for monitoring their parameter of choice (e.g., BP) through the EHR. They specified frequency of monitoring, frequency of RPM value transmission, thresholds to trigger an immediate abnormal reading notification, and a pool of providers to whom the values should be sent. Care Companion (a digital patient journey tool designed using core Epic functionality) sent patients instructions on how to sync their devices and take values, reminders to collect RPM values with the frequency provided, and escalation instructions if their values were outside of system safety thresholds. Patients bought a Bluetooth-connected device that could measure the parameter prescribed, synced the device to Epic using the instructions provided in Care Companion, and had the option to send values either automatically if their device was synced or manually if their device was not successfully synced.

Clinicians reviewing values in the RPM pool (the managing clinicians) were generally the same nurses who managed the practice's pool of patient portal messages, although in some practices, they were pharmacists and in some practices, a single APP managed incoming RPM values. The managing clinicians reviewed values that fell outside of ordering provider or systemwide thresholds as they came in. They reviewed all other values weekly, logging at least 5 minutes per patient per week to meet billing requirements for approximately 20 minutes of review and management of RPM values per month. After reviewing values, managing clinicians escalated to the ordering providers (physicians) any values that potentially required medication changes or other management changes. Managing clinicians also worked directly with patients through patient portal message (at least once weekly) and phone call (at least once monthly) to provide clinical interpretation and education on the basis of the patient's monitored data. This might include lifestyle coaching, medication adherence coaching, education about implications of RPM values for long-term health, education about newly prescribed medications, and device troubleshooting, among other communications. Providers had the option to resolve patient RPM flow sheets and thus prevent further values from coming in, but few providers made use of this capability.

In Phase 2 (July 2022 to June 2023), we aimed to optimize RPM infrastructure and processes guided by practices that had begun deploying RPM. Semistructured interviews and workflow observations helped identify barriers to implementation, which were triaged on the basis of the innovation sweet spot criteria (i.e., desirability, viability, integrity, and feasibility).[20] The team designed and tested interventions for key barriers, which fell into the general categories of patient user experience, technical support, clinician EHR-based experience, and ongoing time management and reimbursement. Key barriers and solutions are discussed below, with more detail provided in Table 1.

Patient-Level Challenge: Onboarding

Interviews and metrics review uncovered a large drop between RPM orders placed and RPM values submitted (only 53.7%; 2,346 of 4,365 patients submitted at least one data point at any time after receiving an RPM order). Interviews revealed this drop to be because of limited insurance coverage of the RPM devices that patients were asked to purchase and vague recommendations around acquiring any Bluetooth-connected device that could measure the requested parameter (rather than a specific device prescription). Additionally, the syncing process itself was very challenging, requiring patients to sync their device to the third-party app it was associated with, then to Apple Health or Google Fit on their smartphone, and finally, to the MyChart patient portal app (on average, 70 clicks across three apps in total).

To address these onboarding challenges (which affected all patients but particularly affected disadvantaged patients with low socioeconomic status, limited insurance coverage, and low digital literacy), we implemented two main interventions. First, we designed and piloted a loaner program with a new practice (an outpatient cardiology practice planning to use RPM to manage hypertension). One year in, the BP device loaner program had been successful, with 64 of 83 patients (77.1%) in this specific program submitting at least one value (this is 29.5 percentage points higher than the general user population at NYULH, which had uptake of 1,617 of 3,394, or 47.6%). Although the loaner program was created to increase our onboarding success rate, it also allowed us to qualify for two additional CPT codes (CPT 99453 and 99454), which helped recoup costs associated with buying and managing the devices. Second, we used a software development kit from a vendor (Validic) to implement direct Bluetooth pairing for select Omron and A&D BP devices. Our software build reduced the number of clicks required to sync devices from 70 clicks across three apps to 10 clicks within one app, and it is being scaled across the health system after a successful pilot (see the Metrics section). This maintains flexibility for patients to buy any Bluetooth-connected BP device and sync to their smartphone using the old pathway (which would require about 70 clicks with three apps), but it also gives providers a clear recommendation for which devices their patients should purchase.

> *"In the basic workflow, physicians and advanced practice providers selected patients who they believed would benefit from remote patient monitoring to better manage their health and placed orders for monitoring their parameter of choice (e.g., blood pressure) through the electronic health record."*

Provider-Level Challenges: Monitoring and Offboarding

At the provider level, we tackled the key barriers of a challenging RPM EHR management workflow, including the limited time available to clinical personnel and the suboptimal allocation of RPM management time. In particular, providers found the EHR In Basket workflow to be inconvenient because they dealt with a constant stream of RPM values and because patients who did not submit values did not show up in the In Basket, with no way to identify and intervene with unengaged patients. To address this, we created a population-level RPM report (one existed before but was nonfunctional because of the way that it was built), allowing for more systematic and efficient review of RPM values than the In Basket approach. We also designed a more streamlined RPM encounter view within the EHR that allows for more efficient review and documentation.

Providers reported that there was a large number of normal, stable patients they were managing every week, resulting in stretching of already thin resources. For example, for BP values in patients in the RPM program in January 2023, 125 of 377 patients (33.2%) had systolic BP values of less than 130 and diastolic BP values of less than 80. The operational team found that there was also a large number of patients no longer transmitting values for at least 3 months: 4,691 of 5,680 (82.6%) as of January 2023. The report workflow that replaced the In Basket workflow provided an opportunity to reach out to these patients and promote engagement, but providers agreed that after 3 months of outreach and not hearing back, it was reasonable to offboard them from the program and reallocate the time to others.

To intervene, the RPM team designed and deployed clinical and automated systemwide offboarding workflows. The clinical workflow provided specific guidance to clinicians on which EHR steps to undertake to offboard patients when they were clinically normal and stable or if they expressed that they no longer wanted to continue in the practice's RPM program. The automated systemwide offboarding workflow consisted of cleanup efforts by the operational team of any RPM episodes that had not received data for at least 3 months. With this, we found a 532.5% increase in RPM episodes that were resolved (from just 8.0% to 50.6%).

System-Level Challenges: Metrics and Scaling

At the system level, a lack of centralized, comprehensive RPM resources was reported by practices. To address this, the operational RPM team created enhanced training materials, including a practice worksheet to help with onboard practices and to help tailor suggested workflows to their resource constraints, a more comprehensive presentation and demonstration, and a comprehensive RPM playbook that could be referred to at any time. We also checked in with practices more closely throughout implementation.

Additionally, a dearth of RPM metrics to understand program status was identified as a key challenge at the system level. This was an ongoing challenge because of the complex structure of RPM data within our EHR (Epic) and the difficulty reconciling submitted RPM values with their associated orders and other patient information. We dedicated significantly increased reporting resources by reallocating personnel to understand the structure of RPM data and build out two new operational reports. We also deployed a patient experience survey to provide additional insight into metrics not available through Epic. Of note, we still only have initial metrics and are actively building out various other metrics on our road map (including more detailed clinical, patient engagement, and demographic data). Throughout Phase 2, we scaled changes through direct communication with practices using RPM and inclusion of updated tools and workflows in our comprehensive RPM playbook.

Hurdles

Continued hurdles being tackled in the current implementation phase — Phase 3 (July 2023 through March 2024 and ongoing) — include the following.

Patient-Level Challenges: Engagement and Technical Challenges

Although the onboarding changes and report facilitating outreach to unengaged patients in Phase 2 increased the proportion of patients who submitted at least one value at any time after receiving an RPM order (uptake), we still face issues with low patient uptake and engagement (reflected by the number of data points submitted per week). We are also actively exploring the use of generative AI to enhance patient engagement and streamline provider workflows in our RPM programs, mirroring the broader research community's efforts. Recent studies demonstrate the significant potential of AI to accurately triage messages in a text-based RPM program[21] and to optimize medication dosing and increase patient adherence and outcomes in chronic disease management.[22]

Additionally, technical challenges with Bluetooth technology occasionally lead to syncing delays. Cellular RPM devices could circumvent onboarding and transmission issues but, at present, are too expensive to scale; cellular devices frequently cost more than $100 plus ongoing data transmission fees, which can be cost prohibitive for many patients and RPM programs. Texting was deemed insecure and not scalable for our program because it would not meet RPM reimbursement criteria.

> *"The team designed and tested interventions for key barriers, which fell into the general categories of patient user experience, technical support, clinician electronic health record–based experience, and ongoing time management and reimbursement."*

Provider-Level Challenges: Patient Identification, Insurance Coverage, and Resource Allocation

It remains unclear which patients would benefit most from RPM, and additional research is needed to answer this question. Questions about insurance coverage are challenging for providers given the fragmented nature of insurance coverage information. Additionally, providers struggle to find RPM management time in practices that treat RPM as a downtime task rather than allocating protected time. The MFM practice group and FQHC primary care practices doing RPM through a trial reported smoother experiences with centralized management for groups of practices monitoring the same RPM values for the same conditions. However, these groups have different payment models than other practices within the NYULH system, so despite the increased efficiencies, their centralized models have been difficult to scale. We plan to further experiment with a more centralized model as part of a large hypertension trial in the primary care faculty group practices. We are hopeful that if we can achieve better patient outcomes and patient satisfaction with reasonable reimbursement, we will be able to advocate for centralization among other interested practices. Of note, we plan to maintain a spectrum of RPM options within our health system to reflect the spectrum of practice types that exist within NYULH. Although there is increasing interest in practices with similar patient populations and RPM use cases centralizing their efforts, there are still many individual physicians and practices that prefer to manage RPM values for their own patients.

System-Level Challenges: Equity and Sustainability

Although piloting a loaner program and direct Bluetooth pairing improved RPM access, equity challenges persist. We have incomplete social determinants of health data within Epic, and the format of the data was historically different within the FQHC and faculty group practices in our system. Continued efforts to standardize, collect, and analyze these data will be key to understanding and intervening on disparities in RPM care within our system. Additionally, we plan to offer our RPM program in more languages. Digital materials are currently available only in English, with incomplete parity in Spanish; we are in the process of expanding our Spanish content and will prioritize other languages prevalent in our communities next.

Additionally, low reimbursement on the basis of the CMS RPM CPT codes continues to provide a challenge to the financial sustainability of the program. Although the loaner RPM program that we piloted unlocked two additional usable billing codes (CPT 99453 and 99454), which helped it do better than other RPM programs within NYULH, reimbursement criteria remain challenging to meet across the board. CPT 99453 requires in-person setup and education, which can be challenging if a trained staff member is not available at the time of a patient's visit. CPT 99454 requires 16 data points per month, and CPT 99457 and 99458 require 20 minutes of review and management time per month. Practices have demonstrated that they can meet these time requirements, but challenges with low patient engagement mean that they do not always receive sufficient data with respect to reimbursement requirements.

CPT 99457 and 99458 also require a minimum of one interactive communication (interpreted by our Revenue Integrity Department as a phone call) per month, which practices have demonstrated that they can do. However, patients do not always pick up the phone, and this can lead to missed billing opportunities, even if 20 minutes of review and communication through patient portal messaging are completed. Moreover, CPT 99457 and 99458 require automated transmission of data. Pathways to submit data automatically are now much easier because of the direct Bluetooth pairing we implemented, but manual data submission still remains the simplest pathway and the only option for patients whose insurance does not cover Bluetooth-connected BP cuffs and who can only afford manual ones. Data from our MFM group showed that RPM improved pregnancy outcomes for patients with gestational diabetes, and there was no difference in outcomes among patients who transmitted glucose values manually versus automatically.[17] This suggests that current reimbursement criteria requiring automated transmission present a barrier to those who have limited insurance coverage and/or limited discretionary income, requiring them to work harder to achieve the same outcomes and disincentivizing providers from enrolling them in RPM programs because of ineligibility for reimbursement if values are manually transmitted.

> *"One year in, the blood pressure device loaner program had been successful, with 64 of 83 patients (77.1%) in this specific program submitting at least one value."*

The Team

The core RPM team consists of NYULH's Strategic Director of Digital Health Innovation (also a clinician and researcher), the Virtual Health Director, the Team Lead and four analysts from the Virtual Health & Epic MyChart team plus the Project Manager and the Project Coordinator. Additional collaborators include clinical partners and members of the reporting, software engineering, user experience, and revenue integrity teams. Research support includes graduate students, a data analyst, and an Assistant Professor in Population Health.

Metrics

NYULH's RPM program grew from 480 RPM orders among 40 providers in 2018 to 3,773 orders among 225 providers in 2023 (Table 2).

Table 2. Growth of Provider Participation and Remote Patient Monitoring Orders, 2018–2023

Participation	2017	2018	2019	2020	2021	2022	2023
Providers	2	40	30	79	148	178	225
Orders	4	480	648	1,372	2,152	2,969	3,773

Source: The authors

The most common parameters are BP (54.5%) and glucose (19.2%) (Table 3).

Program growth has been primarily driven by ambulatory internal medicine (31.1%) followed by MFM (17.0%) and cardiology (7.5%) (Table 4).

RPM use has been driven primarily by superusers (providers whose orders make up at least 1% of all RPM orders) rather than being evenly distributed across providers (Table 5).

Enrolled patients are an average age of 48.4 years old, above New York City (NYC) area's average of 38.4 years old. Among our participants, 69.2% are women compared with 51.9% in the NYC area. When examining racial demographics, most patients are white (45.7%), which is slightly higher than the 37.5% of individuals in the NYC area identifying as white only or the 31.2% identifying as white only, not Hispanic or Latine. They are followed by Black or African American participants, who represent 20.6% of our RPM population, slightly below the NYC area's 23.1%. Additionally, Asian participants account for 7.68% in our RPM program, which is lower than the 14.5% observed in the NYC area for those identifying as Asian only. Moreover, American Indian participants constitute 0.77% of our participants, comparable with the 0.6% of American Indian and Alaska Native only in the NYC area. Pacific Islander participants represent 0.40% of our participants, in line with the less than 0.1% native Hawaiian and other Pacific Islander only in NYC.

Table 3. Remote Patient Monitoring Information Collected by Type, 2018–2023

Information Collected	Number	Percentage
Blood Pressure	6,212	54.5
Glucose	2,190	19.2
Pedometer (Steps)	881	7.7
Weight	721	6.3
Heart Rate	501	4.4
FEV1	283	2.5
Oxygen Saturation	280	2.5
Temperature	236	2.1
Sleep	95	0.8

This information is on the basis of data collected from 8,413 patients from January 2018 to December 2023. FEV1 = forced expiratory volume in 1 second. Source: The authors

Table 4. Remote Patient Monitoring Orders by Specialty, 2018–2023

Specialty	Number of Orders	Percentage
Ambulatory Internal Medicine	3,484	31.1
Maternal Fetal Medicine	1,903	17.0
Cardiology	844	7.5
Family Medicine	813	7.3
Other	4,162	37.1

Other includes 25 specialties, including transplant, obstetrics and gynecology, and neurosurgery, none of which exceed 7.0%. Source: The authors

However, multiracial patients in our RPM program were underrepresented at 0.52% compared with the 8.9% in the NYC area who identify with two or more races. Additionally, 24.3% of patients were "other," meaning either their race was not one of the available options or they preferred not to say. Regarding ethnicity, 27.1% of our patients identify as Hispanic or Latine compared with the 29.0% average in NYC. Insurance coverage among our participants includes 43.9% private, 16.7% Medicare, 21.3% Medicaid, and 20.1% uninsured or self-pay. Patients who spoke a main language other than English were underrepresented at 23.8% compared with NYC's 48%.[23-25]

In the early stages of the program, patient uptake (patients submitting at least one data point) was 2,346 of 4,365 or 53.7%. Within Phase 2, uptake decreased to 1,617 of 3,394 or 47.6% (Table 6).

In comparison, the pilot loaner program had higher uptake of 64 of 83 (77.1%) submitting at least one data point between September 2022 and December 2023. At sites where direct Bluetooth syncing was piloted as a replacement for the traditional Bluetooth pathway, patient uptake rose from 146 of 426 (34.3%) to 161 of 420 (38.3%), with patients submitting at least one data point during April and May 2023 and during July and August 2023, respectively. Time from RPM order placement to initial value transmission (activation time) improved from 7.2 days with the traditional Bluetooth pathway to 4.8 days with direct Bluetooth syncing. Patient engagement (the number of average weekly submissions) across parameter types is displayed in Table 7.

To provide context to the engagement data, patients submit an average of 5.1 of an expected 3–14 BP submissions per week, with differential engagement and adherence across some patient

Table 5. Remote Patient Monitoring Orders by Provider Activity Category

Provider Activity Category	Number of Providers	Percentage of All Providers	Number of Orders Issued	Percentage of Total Orders Issued
RPM Order Superusers	17	0.21	5,917	51.9
RPM Order Users	373	4.5	5,482	48.1
Non-RPM Order Users	7,808	95.2	0	0

Superusers are defined as providers whose remote patient monitoring (RPM) orders make up at least 1% of the total. Other RPM order users includes those who issue at least one RPM order but account for less than 1% of the total. The other users include all Epic users, none of whom issue an RPM order; other users include about 8,000 providers with the authority to issue an RPM order. The number of orders issued represents cumulative sums over the 6-year period from January 2018 to December 2023. Source: The authors

Table 6. Patient Uptake by Data Points Submitted

Phase	Enrolled in RPM	Uptake: Submitting at Least 1 Data Point After Receiving RPM Order	Submitting 0 Data Points
Phase 0 (January 2018 to March 2020)	841 (100%)	252 (30.0%)	1,001 (70.0%)
Phase 1* (April 2020 to June 2022)	3,753 (100%)	2,089 (55.7%)	1,664 (44.3%)
Phase 2 (July 2022 to June 2023)	3,394 (100%)	1,617 (47.6%)	1,777 (52.4%)
Phase 3** (July 2023 to present)	1,609 (100%)	785 (48.8%)	824 (51.2%)

Enrolled in remote patient monitoring (RPM) means that the patient has received an RPM order during that time period; some unique episodes may span more than one phase. *Phase 1 exhibits a higher uptake of RPM, likely because of the increase in telemedicine adoption triggered by the Covid-19 pandemic's onset. Research at our institution supports this observation, documenting a parallel trend in telemedicine's expansion as a pivotal health care solution during the pandemic.[26] **As of February 2024, Phase 3 was ongoing.
Source: The authors

populations (e.g., MFM with 5.6 of 14 expected, Internal Medicine with 3.7 of 3 expected, and Cardiology with 6.2 of an average of 5 expected; different frequencies were used, such as twice a day, daily, and every other day depending on the order) and within the FQHC primary care practices (5.4 of 3 expected, again averaged across the different frequencies used). At sites where direct Bluetooth syncing was piloted as a replacement for the traditional Bluetooth pathway, average weekly submissions rose from 4.9 (December 2022 to June 2023) to 6.6 for patients using the new syncing method (June 2023 to December 2023). The percentage of inactive or clinically normal and stable patients offboarded from the program increased — from 638 of 7,974 (8.0%) before February 2023 to 5,424 of 10,721 (50.6%) after February 2023 — after clinical and systemwide offboarding workflows were implemented, indicating improved resource allocation. Of the 6,062 resolved episodes that resulted from this effort, 4,338 (71.6%) were offboarded through systemwide automated criteria, and 1,714 (28.3%) were resolved clinically.

Systemwide RPM data are difficult to interpret because of significant variability in RPM indications and patient populations across the health system. Each practice is currently tracking clinical outcomes within its RPM use context. Initial data show promising results. For example, a

Table 7. Patient Engagement Across Remote Patient Monitoring Types

RPM Type	Average Submissions per Week
Blood Pressure	5.1
Glucose	23.7
Pedometer (steps)	5.2
Weight	2.7
Heart Rate	191.8
FEV1	6.8
Oxygen Saturation	6.9
Temperature	3.4
Sleep	2.0

RPM = remote patient monitoring, FEV1 = forced expiratory volume in 1 second. Source: The authors higher proportion of MFM patients with diabetes who participated in RPM achieved glycemic control in the target range (285 of 360, 79.2%) versus those who maintained paper logs to bring to their appointments (90 of 173, 52.0%, $P < 0.001$). This may have been influenced by the real-time engagement with the clinician among the RPM cohort participants, who could receive provider feedback or medication titration as necessary. Similar performance was observed in achieving the target range sooner (median 3.3 vs. 4.1 weeks, $P = 0.025$), having lower rates of preeclampsia (21 of 360, 5.8% vs. 26 of 173, 15.0%, $P = 0.006$), and having infants with lower rates of reported neonatal hypoglycemia (107 of 360, 29.8% vs. 89 of 173, 51.7%, $P < 0.001$).[17] Additional data from other practices have been submitted for publication and are forthcoming.

> *"Our software build reduced the number of clicks required to sync devices from 70 clicks across three apps to 10 clicks within one app, and it is being scaled across the health system after a successful pilot."*

A survey (Appendix) of actively participating RPM BP patients from May to August 2023 provides additional insight into the program's value. In September 2023, invitations to participate in the survey were emailed to a total of 491 patients who were monitoring their BP across 83 unique providers. A total of 103 patients opened the survey, with 80 completing it within a 2-week period, an overall response rate of 16%. Seventy-six responses were in English, and four were in Spanish. Using a five-point Likert scale with response choices ranging from Strongly Disagree to Strongly Agree, patients were queried on their BP monitoring habits before joining the RPM program, their behaviors and experiences subsequent to enrollment, and their overall satisfaction with the program. Eighty percent of respondents agreed or strongly agreed with being satisfied with the RPM program, with an overall score of 4.1 ± 0.9 out of 5. Sixty-one percent of patients reported feeling closer to their provider than before starting the program, with a mean score of 3.7 ± 0.9. Eighty-one percent of patients agreed that they had checked their BP more often than before they started the program (mean score 4.1 ± 1.1), 74% agreed that they learned new things about their health (mean score 3.9 ± 0.8), and 70% reported that they felt more in charge of their health since starting the program (3.9 ± 1.0). Sixty percent of respondents reported that before they started the RPM program, they had not checked their BP as often as their doctor recommended or not at all. Additionally, before enrolling in RPM, 20% reported that their method of reporting at-home BP checks to their doctor was to bring a paper log to their appointments.

Where to Start

We offer five suggestions for those operating or considering an RPM program:

1. Identify stakeholders (including those whose voices are at risk for being marginalized, such as patients with language barriers or nursing staff), and involve them early and throughout RPM implementation to understand needs, contexts, and resource constraints.

2. Choose where on the spectrum of a centralized approach (single team managing referred patients) to a decentralized approach (each practice or practice group manages its own RPM patients) your organization best fits on the basis of organizational and resource factors. Decide between building condition-specific RPM programs and building capacity for clinicians to measure parameters of interest. In light of limited reimbursement potential, centralized condition-specific RPM programs likely make the most sense for health systems with large proportions of value-based contracts.

3. Build an end-to-end workflow including program onboarding, device acquisition and setup, data submission and monitoring, billing, and program offboarding.

4. Conduct usability testing with clinicians or practices that are enthusiastic initial adopters and open to iterative cycling. Test, iterate, and refine your program on the basis of both global learning (including what other health systems are doing) and context-specific feedback from individual practices.

5. Consolidate best practices in a playbook, and scale the program across the health system.

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Appendix

Remote Patient Monitoring Patient Experience

Acknowledgments

We thank the Remote Patient Monitoring (RPM) Operational Team, including Emily Reindel, Veronica Gragnano, Amy Stein, Christopher Mahoney, Abbey Bermudez, Jacqueline Harootian-Abdelaziz, and Mojana Elleh, for their contributions to leading the New York University Langone Health (NYULH) RPM program over the years. We also thank Mariel Shull and Lisa Anzisi as well as Hye Heo and the Maternal Fetal Medicine team, John Dodson and the NYULH Cardiology Associates 9U team, Antoinette Schoenthaler and the ALTA (Advancing Long-term Improvements in HTN Outcomes through a Team-based Care Approach) team, Lisa Groom, Natalie Henning, and the HiBRID (Healthcare Innovation Bridging Research Informatics and Design) and Digital Solutions Teams for their work in scaling NYULH's RPM program.

Disclosures: This work was supported in part by National Science Foundation (NSF) awards 1928614 and 2129076. Nina Singh, Katharine Lawrence, Katerina Andreadis, Chelsea Twan, and Devin M. Mann have nothing to disclose.

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