

Table S2. Perceived Facilitators and Barriers to Incorporating Remote Monitoring Technologies into Routine Patient Care as Expressed by Clinicians, Administrators, and Staff

GROUP PERSPECTIVE, REFERENCE (YEAR)	FACILITATORS	BARRIERS
Primary care clinicians		
Goodrich et al. ¹⁶ (2011)	<ul style="list-style-type: none"> • Clinicians and staff perspectives combined • Both physicians and medical assistants indicated RMT was functional and informative and that graphical display was effective. • Once providers logged to RMT, providers found the interface easy to use and reported "enough basic info" was present to quickly check patient progress. 	<ul style="list-style-type: none"> • Lack of integration of RMT and the clinics' EHR limited clinicians' use of the data. • Accessing RMT was not convenient; it took time during the clinic visit to find the Web site and log in (e.g., remember username and password). • Several providers requested e-mail alerts to help prioritize review of specific patient records for situations that could benefit from follow-up or encouragement (e.g., a medical event affecting walking, low program participation, or a scheduled clinical encounter). • Lack of time to cover physical activity discussions during brief patient visits
Kobb et al. ¹⁹ (2003)	<p>Only three measures on provider satisfaction were reported:</p> <ul style="list-style-type: none"> • Is communication between yourself and care coordinator timely/appropriate? 98% Yes • Is the project a benefit to your patients? 100% Yes • Would you refer patients to this project? 100% Yes 	NR
Langstrup ²⁰ (2008)	The RMT asthma portal served as an educational tool for the patients.	<ul style="list-style-type: none"> • Clinicians disagreed with the system's alerts and clinical decision support. • The RMT was not used as a shared platform for doctors and patients. Clinicians conveyed a lack of interest in using the data submitted by patients.
Liddy et al. ²¹ (2008)	<ul style="list-style-type: none"> • For physicians, having notes on patients' use of RMT devices and patient RMT data available in their charts during clinic visits was helpful. • Physicians felt the Care Companion benefited patients by providing feedback on physiologic data. • NPs found the alerts helpful for identifying emerging health issues, monitoring long-term trends, and reducing the need for office visits. • One NP suggested short-term use of the equipment when medications are being switched, then to move it to another patient. 	<ul style="list-style-type: none"> • Physicians were concerned about the medicolegal liability associated with receiving time-sensitive data (e.g., response time to critical values). • The reliability and calibration of the RMT equipment was sometimes a concern for NPs, physicians, and patients. Some patients continued using their own glucometers instead and manually entered the numbers into the device.
Terschuren et al. ²² (2007)	<ul style="list-style-type: none"> • PCPs benefited from reduced workload by avoiding unnecessary home visits, and by delegating monitoring tasks to the community medicine nurse with the backup of the measurements obtained by the RMT devices. 	NR
Van den Berg et al. ²³ (2009)	<ul style="list-style-type: none"> • All participating clinicians and RNs found the implementation of RMT useful for eligible patients. • The clinicians were only involved in selecting the patients and assessing alarm values; therefore there was no additional workload for the clinician. • RNs benefited from increased agency and professional autonomy. 	NR
Staff and administrators		
Abraham and Rosenthal ¹³ (2008)	<ul style="list-style-type: none"> • Program personnel felt that RMT successfully met the needs of its enrolled patients and made data collection and analysis more efficient for physicians and nurses, allowing more efficient use of time and better diagnoses in clinical and emergent care. • Staff noted patients' increased self-awareness of their own medical status as a benefit of RMT. • To avoid overwhelming providers and case managers with excessive data, a program support assistant compiled quarterly summary e-mail reports for providers about the conditions of their patients using RMTs. 	<ul style="list-style-type: none"> • RMT data were not always available when needed, which raised the need to integrate data between RMT information systems and the EHR. • The 1:125 staffing ratio (specified by the VHA Office of Care and Coordination) of LCC to enrolled patients was perceived by program personnel to be inadequate. Based on the actual time required to enroll patients, review the daily data submitted by each patient, and complete all additional medical/administrative requirements on a daily/weekly basis, the study authors calculated that the LCC must dedicate approximately 62.88 h/week to support 125 RMT program enrollees.

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Furuse et al. ¹⁴ (2008)	<p>The primary healthcare team (roles not specified) reported improvements in healthcare management resulting from the data feedback loop to patients (such as blood glucose readings) and findings that prompted clinical interventions.</p>	NR
Gagnon et al. ¹⁵ (2006)	<ul style="list-style-type: none"> Providers identified benefits such as better follow-up and diagnosis, detection of other health problems, and improved communication with patients and other providers. Nurses in Project 1 felt greater professional autonomy because special agreements allowed them to perform tasks usually restricted to physicians. Project 3: NA 	<ul style="list-style-type: none"> Issues such as healthcare professionals' remuneration, liability, and licensing were noted regarding RMT. Project 1: Project managers may underestimate the amount of time required to implement remote monitoring and the need to involve all personnel affected by the project. RMT activities were conducted somewhat independently from regular homecare services. Better integration of telehomecare activities with other nursing services is needed. Project 3: NA
Hicks et al. ¹⁶ (2009)	<ul style="list-style-type: none"> The RMT was viewed as convenient, decreasing the need for visits. RMT had a positive impact on the staff's communication and relationship with clients, caregivers, and family members. 	No information on barriers. One staff member at the home health agency elected not to use the RMT after being trained, but no information was given about the reasons for nonuse.
Lamothe et al. ²⁴ (2006)	<ul style="list-style-type: none"> Healthcare professionals (not specified as PCPs) unanimously indicated that the daily readings of a patient's clinical parameters and timely identification and response to alerts helped establish or confirm a diagnostic or therapeutic conduct or adequate monitoring. Doctors found visual presentation of weekly and monthly readings in graphs to be helpful. Remote monitoring stimulated more efficient networks of communication between patients and caregivers and between hospital and homecare nurses. RMT sometimes led to more professional autonomy for nurses (e.g., preauthorized prescriptions for antibiotics). 	<ul style="list-style-type: none"> Responding to <i>ad hoc</i> patients' needs and alerts in addition to pre-established interventions plans presents a challenge for managers and providers. The expansion of services requires specialized clinical competencies (e.g., understanding of equipment, specialized care needed, etc.) that pose difficulties in personnel scheduling. Continuous education of nurses in various complex clinical conditions may become problematic.
Langstrup ²⁰ (2008)	In some cases, the RMT served as a nurse intervention tool for establishing a connection between nurse and patient. In one example, the patient chose not to enter daily data, but instead accumulated peak flow readings on paper and only entered them just before her appointments with the nurse.	<ul style="list-style-type: none"> In a nurse-patient case example, the RMT afforded the opportunity to follow the patient more closely but also added complexity to care. An inconsistency between RMT data and the clinical picture of the patient's asthma necessitated more, rather than fewer, visits to the clinic. System alerts were viewed as unhelpful; in 1 case the patient's change in readings were caused by a common cold, so the nurse ignored the program's automatically generated prompt to contact a specialist.
Van den Berg et al. ²³ (2009)	<ul style="list-style-type: none"> In the German primary care system, the clinician can choose to delegate home visits to RNs under certain restrictions, but liability issues and insufficient reimbursement for home visits by staff have limited use of this approach. In this study, practice assistants (RNs) were responsible for training the patients, installation of the devices, and controlling the data obtained. The clinician was alerted only when values exceeded preset thresholds. RNs benefited from increased agency and professional autonomy. 	NR
A mix of healthcare roles or clinical specialties		
Hardisty et al. ¹⁷ (2011) Peirce et al. ²⁷ (2011)	<ul style="list-style-type: none"> Informants suggested that technologies could improve early detection but stressed the need for individual baselines and for using trends and multiple signals. Clinical informants valued qualitative parameters, such as changes in activity levels or appearance as sensitive indicators of deterioration. These may be more useful than simple thresholds. 	<ul style="list-style-type: none"> Informants conveyed that RMT data were often collected without a clear aim or consideration of relevance and that questions important to clinicians were not sufficiently addressed. Without a clear clinical need, it is difficult to establish system acceptability. Medicolegal issues were a significant concern: who takes responsibility for the accuracy of the detection system and for taking the correct clinical response. Most current RMT systems use simple thresholds for triggering an alert (e.g., a nurse inspects the data), and there is little automated analysis. Informants suggested developing protocols with response hierarchies related to alert severity.

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Kim et al. ²⁵ (2011)	<ul style="list-style-type: none"> • Providers valued the ability to gauge a patient's condition through relay data and respond to emergency situations. • Providers perceived remote monitoring in medically underserved areas as efficient. • The authors proposed the need for a clinical interface for making decisions using information from various sources, with capabilities that enable access to previous diagnosis, drug administration and test results, drag and copy function for duplicate drug administrations, and fast response time for opening up data. • Easy visualization of patient data with options based on user preferences is critical. • Active participation of medical staff that will be using the equipment in the field is crucial when designing the interface. • System alerts for detecting deteriorated conditions would be helpful. • Other priorities that were noted included safety and standardization of equipment, appropriate reimbursement and legal support, flexible service personalized to each patient; involvement of stakeholders, and a business model that addresses customers' needs. 	<ul style="list-style-type: none"> • Providers expressed concerns about the added pressure of reading monitoring data and noted that decreased patient contact could lead them to miss signs of deterioration and result in aggravation of medical condition and lowered quality of care. 24-h service provision and increased contacts with patients may increase stress and burden on providers. • Other concerns included that implementing the new technology, training, and integrating with existing systems can be burdensome and inefficient, unclear designation of medicolegal responsibilities (e.g., 24-h service but limited staffing and reimbursement), and the potential for perceived discrimination for patients who make appointments weeks prior to visits versus those who receive service over the phone or Internet.
Thompson and Thielke ¹¹ (2009)	<ul style="list-style-type: none"> • Providers emphasized that the most useful monitoring relates to reversible causes: if no action can be taken to correct the problem, there is no reason to gather the information (e.g., can a person benefit from being able to walk faster?). • Providers conveyed that they prefer to be informed only if there is a pattern of problematic behavior (e.g., multiple missed doses of medications), stating, "I only want to know if there's something wrong." • Providers differentiated between monitoring for clinical practice and monitoring for ongoing care, with different roles for providers versus families or caregivers. A one-time missed dose of medication might just alert the caregiver who could then follow up, but if a consistent pattern develops over time, the clinician should be engaged. 	<ul style="list-style-type: none"> • Participants described several concerns about using RMTs rather than human contact, such as the risk of worsening the isolation, loneliness, and morale of older adults. • Adding burden to caregivers and providers, who would be expected to track and act on information, was a concern. One participant noted that even 30 s of added time to review monitoring data could be too much in the process of care. • One participant expressed doubts that objective technologies would improve our understanding of human behavior and that monitoring older adults could lead instead to the recognition that many adverse events happen randomly, and thus cannot be prevented. • Participants emphasized that older adults often have physical limitations with using electronics (e.g., reading small type or pressing small buttons) that may prohibit adoption.
Ure et al. ²⁶ (2012)	<ul style="list-style-type: none"> • Health professionals perceived the technology as being able to detect the early signs of an exacerbation of COPD. • Oximetry was perceived to be useful, although lung function measures were considered to be unreliable and/or uninformative. 	<ul style="list-style-type: none"> • The risk of overtreatment and medication side effects was a concern, due to increased prescribing of antibiotics and steroids in response to increased recognition of exacerbations. • Clinicians recognized the limitations of a standardized threshold and the need to interpret patient scores in context and noted increased workload in terms of telephone calls or visits made to clarify the individual clinical situation when the score triggered a threshold response. In 1 case a patient intentionally entered lower than actual symptom scores to avoid bothering her healthcare providers. • Clinicians perceived the design of the interface to be constraining and time-consuming. One informant noted the preference to see all patients' data at a glance rather than having to navigate through several screens.

COPD, chronic obstructive pulmonary disease; EHR, electronic health record; LCC, lead care coordinator; NA, not applicable; NP, nurse practitioner; NR, not reported; PCP, primary care physician/clinician; RMT, remote monitoring technology; VHA, Veterans Health Administration.