

2014

# Effect of home telemonitoring on glycemic and blood pressure control in primary care clinic patients with diabetes

Richelle J. Koopman  
*University of Missouri*

Bonnie J. Wakefield  
*University of Missouri*

Jennifer L. Johanning  
*Washington University School of Medicine*

Lynn E. Keplinger  
*Durham Veterans Administration Healthcare System*

Robin L. Kruse  
*University of Missouri*

*See next page for additional authors*

Follow this and additional works at: [https://digitalcommons.wustl.edu/open\\_access\\_pubs](https://digitalcommons.wustl.edu/open_access_pubs)

---

## Recommended Citation

Koopman, Richelle J.; Wakefield, Bonnie J.; Johanning, Jennifer L.; Keplinger, Lynn E.; Kruse, Robin L.; Bomar, Marilee; Bernt, Beth; Wakefield, Douglas S.; and Mehr, David R., "Effect of home telemonitoring on glycemic and blood pressure control in primary care clinic patients with diabetes." *Telemedicine and e-Health*.20,3. 253-260. (2014).  
[https://digitalcommons.wustl.edu/open\\_access\\_pubs/4712](https://digitalcommons.wustl.edu/open_access_pubs/4712)

---

**Authors**

Richelle J. Koopman, Bonnie J. Wakefield, Jennifer L. Johanning, Lynn E. Keplinger, Robin L. Kruse, Marilee Bomar, Beth Bernt, Douglas S. Wakefield, and David R. Mehr

# Implementing Home Blood Glucose and Blood Pressure Telemonitoring in Primary Care Practices for Patients with Diabetes: Lessons Learned

Richelle J. Koopman, MD, MS,<sup>1</sup> Bonnie J. Wakefield, PhD, RN,<sup>2,3</sup>  
Jennifer L. Johanning, MPH,<sup>4</sup> Lynn E. Keplinger, MD,<sup>5</sup>  
Robin L. Kruse, PhD,<sup>1</sup> Marilee Bomar, APRN,<sup>1</sup>  
Beth Bernt, RN, BSN, MBA,<sup>6</sup> Douglas S. Wakefield, PhD,<sup>7-9</sup>  
and David R. Mehr, MD, MS<sup>1</sup>

<sup>1</sup>Curtis W. and Ann H. Long Department of Family and Community Medicine, University of Missouri School of Medicine, Columbia, Missouri.

<sup>2</sup>University of Missouri Sinclair School of Nursing, Columbia, Missouri.

<sup>3</sup>Iowa City Veterans Administration Healthcare System, Iowa City, Iowa.

<sup>4</sup>Washington University School of Medicine, St. Louis, Missouri.

<sup>5</sup>Durham Veterans Administration Healthcare System, Durham, North Carolina.

Departments of <sup>6</sup>Internal Medicine and <sup>7</sup>Health Management & Informatics, University of Missouri, Columbia, Missouri.

<sup>8</sup>University of Missouri Informatics Institute, Columbia, Missouri.

<sup>9</sup>University of Missouri Center for Healthcare Quality, Columbia, Missouri.

*The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the Agency for Healthcare Research and Quality, the Department of Veterans Affairs, or the U.S. Government.*

*This study has been presented in part at the Society of Teachers of Family Medicine Annual Conference, held in Seattle, Washington, in April 2012.*

## Abstract

**Background:** Prior telemonitoring trials of blood pressure and blood glucose have shown improvements in blood pressure and glycemic targets. However, implementation of telemonitoring in primary care practices may not yield the same results as research trials with extra resources and rigid protocols. In this study we examined the process of implementing home telemonitoring of blood glucose and blood pressure for patients with diabetes in six primary care practices. **Materials and Methods:** Grounded theory qualitative analysis was conducted in parallel with a randomized controlled effectiveness trial of home telemonitoring. Data included semistructured interviews with 6 nurse care coordinators and 12 physicians in six participating practices and field notes from exit interviews with 93 of 108 randomized patients. **Results:** The three stakeholder groups (patients, nurse care coordinators, and physicians) exhibited some shared themes and some unique to the particular stakeholder group.

Major themes were that practices should (1) understand the capabilities and limitations of the technology and the willingness of patient and physician stakeholders to use it, (2) understand the workflow, flow of information, and human factors needed to optimize use of the technology, (3) engage and prepare the physicians, and (4) involve the patient in the process. Although there was enthusiasm for a patient-centered medical home model that included between-visit telemonitoring, there was concern about the support and resources needed to provide this service to patients. **Conclusions:** As with many technology interventions, careful consideration of workflow and information flow will help enable effective implementations.

**Key words:** telemedicine, diabetes, hypertension, care management

## Introduction

The chronic care model emphasizes clinical care management and self-management support for complex patients.<sup>1</sup> For patients with type 2 diabetes, home monitoring of blood pressure (BP) and blood glucose (BG) may be part of a disease self-management program. Between-visit communication about these data by the patient–healthcare team may facilitate the interaction of an informed, activated patient with a prepared, proactive team, which is an integral part of the chronic care model.<sup>1</sup> This interaction may also help overcome “clinical inertia” that leads to treatment intensification delays.<sup>2</sup> Capabilities for uploading home BP and BG data using the Internet and mobile technologies are proliferating.

Most investigations of BG and BP telemonitoring show some improvement in BP and glycemic control,<sup>3–11</sup> but they generally occurred within the context of a structured research protocol with research personnel acting as intermediaries. Little information is available about how to incorporate these activities into real-world primary care practice.<sup>12</sup> Practices that seek to use telemonitoring to improve care need to know who should receive these data and in what form, how data should flow to the patient’s provider, how much time office personnel will spend troubleshooting technical problems, and how burdensome these activities will be to members of the healthcare team.

Many previous models have used nurses to review home telemonitoring BP and BG data rather than having the raw data go directly to the physician.<sup>13</sup> Previous research shows a distinct possibility of low physician attendance to these data.<sup>3,14</sup> In our 3-month randomized trial of BP and BG telemonitoring among patients with diabetes attending six primary care practices, practice nurses

received, reviewed, and communicated with physicians and patients about transmitted data. To address the need for information about telemonitoring implementation in clinical practice, we focus here on the experiences of the nurses, physicians, and patients who submitted, received, and reviewed these home BG and BP data. Previous examinations of primary care telemonitoring implementations have been limited to examinations of feasibility and acceptability,<sup>15–17</sup> a single stakeholder perspective,<sup>15,18,19</sup> or centralized monitoring by research personnel not well integrated with the primary practice site.<sup>20–22</sup>

The clinical trial that is the background for this work was very much an effectiveness trial. While a research assistant enrolled patients and collected data, all other functions of the telemedicine implementation were performed by existing personnel in these six internal medicine and family medicine practices. We present a 360° qualitative examination of implementation from the perspective of practice nurses, physicians, and patients. These practical considerations can inform “real-world” primary care practices considering telemonitoring implementations.

## Materials and Methods

We conducted this qualitative inquiry in parallel with a randomized controlled trial of electronic transmission of home BG and BP measurements to the practices. Using electronic medical record (EMR) registry data, we selected adult patients with type 2 diabetes of at least 1 year in duration with systolic BP >130 mm Hg and/or glycosylated hemoglobin A1c >8.0% (see our accompanying article<sup>23</sup>). Patients randomized to the intervention were asked to measure their BG and BP at least once a day, or at greater frequency if directed by their physician, and to transmit BG and BP values to a secure server at least every other day. The transmission device could be attached to an analog telephone line or via USB to a computer for upload to a secure server and associated Web site. Control patients were asked to monitor every day and bring a list of values to any clinic visits occurring during the study but were not given the ability to upload data electronically.

Nurses in participating practices accessed patient BG and BP data on the secure Web site at least twice weekly, but data did not flow directly to the EMR. Nurses communicated pertinent data to the patient’s primary care physician and gave subsequent feedback to the patient. Physicians had access to the Web site. Three of the six nurses were advanced practice nurse partners and could make independent therapy decisions, although they work in partnership with physicians as care managers rather than maintaining their own panel of patients. The payment model setting for the practices was fee-for-service. The research plan was approved by the University of Missouri Health Sciences Institutional Review Board.

Physician and nurse participants provided semistructured in-person qualitative interviews about their experiences. Six nurse participants from two internal medicine and four family medicine practices included three advanced practice nurses, two registered nurses, and one licensed practical nurse; these were all of the nurses involved in this telemonitoring intervention. Twelve general internal

medicine and family physicians were interviewed, representing half of the physicians involved in the intervention. All physicians were invited to be interviewed. Interviews were concluded after reaching saturation. Of the 108 patients randomized, 93 participated in a brief telephone exit interview about their experience. Nurse and physician interviews were audiotaped and transcribed by an experienced qualitative transcriptionist. The research associate (J.L.J.) took notes on each patient exit interview and summarized notes after each call.

Nurse, physician, and patient interviews were analyzed using grounded theory qualitative methods assisted by nVivo 8.0 software (QSR International, Doncaster, Victoria, Australia). Three experienced qualitative investigators (R.J.K., B.J.W., and J.L.J.) independently coded all interviews, then met after every few interviews to first establish and refine a codebook, and then met to reach consensus on codes. R.J.K. is a family physician clinical researcher, B.J.W. is a nurse PhD with telemonitoring expertise, and J.L.J. is a research associate with a master’s degree in public health. They identified major themes and shared findings with the larger group of investigators. The group reached consensus on major themes represented in the interviews and assimilated these into recommendations.

## Results

The qualitative analysis of the nurse, physician, and patient interviews yielded the following four major themes and listed sub-themes. Some identified issues were important for all three stakeholder groups, whereas others influenced only one or two of the user groups. Supporting quotes are provided in *Table 1*.

### CHALLENGES IN DEVICE CONNECTIVITY AND USABILITY

*Telemonitoring is not “plug and play”:* patients will have issues hooking up and using the technology. Computer and analog phone configurations worked well for some patients and not for others because of inherent characteristics of their phone line, Internet service, computer hardware, or already installed software. Patients needed appropriate hardware, software, and Internet connections to upload information. For those who used an analog phone line, the device needed to be connected to the line, but some lines did not support the device. Alternatively, those who used the Internet to upload had to overcome device–computer–Internet connection difficulties. Furthermore, many patients were not eligible for the study because they did not have a glucose meter that was compatible with the system. Issues with compatible glucose meters also contributed to patients’ technology burden. Some patients found the setup was quite easy and did not seem to have any problems. Others struggled mightily, necessitating multiple calls to the research associate and the vendor’s technical support team. Thus, patients had variable experiences with the technology that did not necessarily seem to correlate with their technology skills.

There were also problems with peripheral devices—either the patient’s own BG meter or the study-supplied BP cuff. A surprisingly large number of patients reported suspected inaccuracy of the BP device, an upper arm cuff from a reputable brand. Patients noted

**Table 1. Identified Themes and Supporting Quotes**

THEME, QUOTES
Telemonitoring is not "plug and play": Patients will have issues with hooking up and using the technology.
Patient said everything went fine once he was able to get started. However, he did have to get technical support several times: three times from the telemonitoring service provider and five times from the research associate. The problems stemmed from several issues—the patient could not identify Internet Explorer installed on his computer and then did not recognize the need to install the ActiveX controls when doing uploads. Also, he did not have his meter set to the right date—said his meter doesn't display the year when setting the date and time, just shows the two digit year so he overlooked it. The year setting was incorrect for 17 measurements, and he said it took them a whole weekend to research it. Once he got going he said that he did uploads pretty much every day, and he would try to double-check on the following day that everything went through ok. He generally felt positive about the experience after all of the problems at the beginning were resolved. (Patient 40)
This patient had lots of trouble with the BP monitor; she felt like her readings were always too high. She switched out her cuff during her study period. She said she took her BP lots of different places (mentioned Sam's, the grocery store, her doctor's clinic, and the clinic where she worked), but the one she had at home was always higher. (Patient 8)
Patient had trouble with the first BP cuff she was given to use. She thought the second one was ok but thinks it ran about 10 points higher than in the clinic. (Patient 11)
Nonintegration of your telemedicine system with your EHR will cause someone a lot of extra work.
R: I would have to go in and do a phone message about the data. So that's more work. [chuckle]
I: Taking data from that.
R: Right.
I: Would you typically then like write it down on a piece of paper and then enter it? Or did you have them both open at the same time?
R: Usually I would write it down, and then do the averages, and then put it in the phone message.
I: So kind of transcribe and transcribe.
R: Right. Because my screen is not very big. [laugh] (Nurse 5)
R: To look at the information, summarize the information, and put it in the document. If it was integrated in PowerChart, it would make a big difference because both the doctor and myself could look at it in real time and not have the time that it takes.... And it would depend on how it's presented. It has to be easy to use or else it's not going to be helpful.
I: So sort of the transcribing of information?
R: Mm hmm. Yeah. Yeah. That was more time consuming than I think if you wanted to use it on a larger scale. So I think that that would be one thing that would need to be changed. (Nurse 1)
I: Were you able to cut and paste information out of the Web site into PowerChart?
R: I didn't do that. And maybe that's my skills there probably aren't too good. So I didn't do that. It was more like taking notes or printing it out. But I really got tired of printing out the stuff because it was just so much paper. And so it seemed like it was easier just to sort of—I kept a... I think I usually kept a little pad with patient's names that I had enrolled. I just kind of would put a date and when I reviewed it, and then what the averages were, and make notations. I really used that more. I just kind of created my own little notebook tracking system. (Nurse 4)
Assess system usability and displays. Does the system give means and outliers? Alerting capabilities?
A couple of changes that I think are imperative is the screens are not the same toolbar across the top. So if you want to change something, some screens are interactive and some are not. It makes it difficult to know where you have to go back to, to get what you want. The other major issue is that the blood sugars, they do a great job of giving you averages, but they do not do that for blood pressures. It's beyond me; if you can program it to do it for blood sugars, why you can't do it for blood pressures...When you look at things over time, you want to know, "Has their average changed?" If you're looking at diabetics and you want their average to be 130/80 or lower, and you've got some out of range but their average comes out OK, you're still OK. But to have to do that hand figuring, it's time consuming. (Nurse 1)
Define the flow of information and how it will affect nurse and doctor workflow
Well, if we had a number of patients using this kind of a system, someone would have to be designated to be reviewing them on a regular basis and communication with the patient. So there'd have to be a designated person. It could be me. It could be someone else. And then also determining with the physicians how they want that information communicated to them and what their expectations are, and what the time frame would be that you would expect to hear from them—those kinds of things. (Nurse 4)
I remember it seeming a bit intrusive, outside of my usual workflow, to get an e-mail from the nurse with glycemic readings. Because I wasn't thinking about that patient. I wasn't thinking about their control. And so it was a change in how I got the data, and yet, of course I was going to do something about it. So it was just an addition to what I would ordinarily do. Don't know that it was an improvement. I think again it probably was in at least one. So to make it useful in an ongoing setting I think we would need to have some deliberation about how to make it part of the clinical work flow as opposed to just one more phone message coming in with lots of data that I have to make sense of and do something about. (Physician 7)

continued →

**Table 1. Identified Themes and Supporting Quotes** *continued*

THEME, QUOTES
It's honestly probably not the best use of my time to actually be in the data gathering, to look through three pages of blood pressures. I'd probably like it; I think it would be a more appropriate use of my time to have it synthesized. (Physician 9)
Electronic transmission of data will not eliminate the need for real-time communication and relationship building.
I think most of my communication was by telephone. I would call the patients and tell them if the physician needed them to change something. Occasionally, I would just call and tell them I'm monitoring it if we didn't make any changes just to let them know that we were watching it even though we hadn't made any changes in their regimen. (Nurse 3)
I still have to call the patients because I need to find out what they're doing as far as diet, activity, those sorts of issues, and then to find out if they're truly taking their medicines and those sorts of things. It does help to have the numbers ahead of time. It may then base my questions a little more to the point. (Nurse 2)
Educate physicians and staff about the evidence for telemedicine interventions
Most of the time, love seeing the numbers, and I think it's helpful. Although I wonder if that's really all that's needed for someone who isn't on insulin anymore because there's more data that suggest that people that have diabetes that aren't on insulin, you just need to follow their A1Cs, you don't need to follow their blood sugars... In general, I think people being in charge of their own healthcare, their own chronic conditions, and monitoring, that is great. If there's a way that that can help them get that information to me, that would be great. If it is shown that those kind of monitoring systems can help improve people's quality of life, the way they feel, their disease control, great. I just don't know that that's—I don't know whether or not that's been proven or not. (Physician 1)
I'm not necessarily sure that that should come out of clinic budget, just because it's like cooler and techier for you to upload your [chuckle] blood sugars to this Web site. I'm not really sure that it—I guess I'd want to see that it definitely gets you better blood pressure or blood sugar control before the clinic would ever invest in those devices. (Physician 9)
Be prepared to do between-visit care and treatment adjustments
It was very useful. In helping to make adjustments; in monitoring people; in having—not having a—what do I want to say? A surprise in 3—sometimes we see people 3 months, sometimes 6 months, depending on how controlled they are with their blood sugars or their blood pressure. So not having a surprise in 3 months...when they come into clinic. And in fact I just had this happen just the other day, and I thought, "Darn. I wish I had had this person on the smart device study." She came in and she said, "I decided to quit taking my insulin." Ooh! (Nurse 1)
I think it saved some visits back to the physician because we were able to make some changes by phone, to keep them from having to come in and be seen to do that. (Nurse 3)
Because you can tweak things, adjust medications, rather than having them wait 6 months or 3 months when they come in, and I think you can get a tighter control. That way they also know that you're kind of keeping an eye and you're paying attention to it. It means something to you. It's more of an incentive for them to keep track of it for you. (Physician 3)
Telemedicine interventions may not be well received by providers in a fee-for-service model.
The payment model doesn't, and the work expectations don't. I mean because honestly, it is at this point in the development of an expanded primary care model, this is just an add-on. I mean I don't see two fewer patients so that I can go through all these messages or anything like that. It just becomes an add-on. And that's of course what you hear many primary care physicians lamenting, "This is just one more thing that I have to do that I don't get paid for." (Physician 2)
Unfortunately, it's another cost added to the people who are already overloaded with a lot of other things that aren't already getting reimbursed. I'm sounding a little cynical about this, and I don't really intend to. But in a way, I feel like I have to defend the future of family medicine. And the future of family medicine is not good if we don't figure out a different way of doing this. (Physician 13)
I can see a home health agency, and I know that they are already, kind of getting into this business. Where they're going to go lend people or rent people these devices at a high price. And then all that's going to mean is they're going to send you back another sheet of paper with another unfunded mandate of having to respond to another agency that's billing for their services and expecting us to provide decision support without getting paid anything for it. Which is what we do with home health agencies, nursing homes, hospices, and everybody else. We've got to reduce that amount of work, not increase that. (Physician 13)
Advanced practice nurses may enable the intervention through co-management strategies with the physician.
This is much more suited to an APN who can view the data and actually make changes to the patient's regimen. As an RN, I'm limited as to what I can advise and change. Being a messenger is frustrating in that I don't know that I am sending the provider all the information needed to make a change in the regimen. It would seem that if the provider can see the info directly, they can make better decisions about changes in the care. (Nurse 2)
I think having nurse clinicians who can... so a midlevel provider who could help with the fine-tuning face to face with the patient because I think the patient gets a lot of value out of that. So some interim visits in between physician visits or more frequent physician visits to actually talk about it rather than handling it via a phone call. Now again, I don't know if that serves the patient better because that means more appointments for them. And that gets back to just the payment model. If we do it outside of the clinic visit then we're donating that time. (Physician 7)
Choose appropriate patient candidates
I think for the frequently out of control and the...sometimes out of control, that's where we can make the most difference. If they're doing OK, not necessarily—I don't think they're as much monitoring value. Now, let me just say that if for some reason we were changing their regimen, it would be good to do that even if they were within control. So if we were taking—I'll give you a specific example. If we were taking a patient from 70/30 insulin to Lantus® [insulin glargine] [Sanofi-Aventis, Paris, France] and NovoLog® [insulin aspart] [Novo Nordisk, Bagsværd, Denmark], it would be helpful to have a system like the smart device system. (Nurse 1)

continued →

**Table 1. Identified Themes and Supporting Quotes** *continued*

THEME, QUOTES
<p>But I think sometimes you know things about the patient's social situation that you just think, "You know what? They don't need that in their life right now. Their husband's dying of cancer. They don't need to have this thing. They don't need to have someone bugging them at home." On the other hand, maybe they do. Maybe it'd be a wonderful kind of social support for them. So there's social things that might make a patient inappropriate. There might be medical things that you don't...their diabetes is the least of their problems, and so you don't even want to...that's not something that are worried about right now or they're worried about right now. Or cognitively, they may not be able to follow instructions. And you know they don't have any access to the Internet. So that's an issue. Those would be some of the features that I would think about when I'm deciding not to encourage somebody to give them a call. (Physician 1)</p>
<p>And you've got somebody who's very poorly controlled in terms of their diabetes. And particularly when you're starting them on insulin. I think that this is a helpful thing because you're adjusting their insulin regularly and frequently. I mean you're going to want that kind of feedback. I mean you can't just start them on 15 units of Lantus and "Come back and see me in 3 months." (Physician 13)</p>
<p>Encourage patients to become active managers of their own care</p>
<p>I can remember a gentleman who said, "I just don't think my pasta dinner makes any difference,"...and so I said to him, "I want you to do me a favor. In the next 2 weeks, I want you to have pasta dinner three times." And so that's no problem. I had him take his blood sugar before his meal and 2 hours after he completed it. He came in the next week, and he brought me something. He said, "I now see what you mean about my pasta dinner. Yeah. It was just too much carbohydrate load." And he was willing then to switch to a different kind of pasta. But he was a fairly newly diagnosed diabetic, and so he just didn't think that the meal would make that much difference. And I've got people with exercise issues like that too. I wish they'd just take—and then I could see it on the screen and call them in a short period of time, "Hey. I see that you" if they had corresponded and said, "I took a walk for however long, and this was my blood sugar before, this was my blood sugar after," I think we could make a difference. (Nurse 5)</p>
<p>And what he told me was what was most helpful for him was he was actually seeing it. And having to put it in every day, and he was accountable. (Nurse 4)</p>
<p>He's a funny guy because he'd say something like, "Yeah. I was checking my blood sugars and I was doing better." I'm like, "No kidding. You mean, gee, why do you think that was?" And so he'd start laughing and just trying to draw the relationship for him about how he's paying attention to his health and how his health outcomes were improving as a result of him paying attention to his health. So trying to complete that sort of insight for him. Because sometimes he'd act like, "And then a miracle happened and I was given a machine." And so instead of—that it wasn't a machine, it was the fact that he was participating in his care. Wasn't that wonderful that he was doing that, and that he was really caring. Yeah. Wow. That's so great. And so he got that. And maybe he got it before I teased him about it. But just about how, yeah. Isn't that great when you're doing things for yourself then that can really make a difference. And so, "Way to go. I'm glad you figured that out. I'm glad that that worked for you." That was a really good little "Ah ha!" moment for him and me maybe. (Physician 1)</p>
<p>Also said it did make him more aware of his fasting blood sugars, especially in the morning after he had gone out to eat late the night before with no exercise in-between. (Patient 45)</p>
<p>Develop strategies with patients to integrate with daily life and routines</p>
<p>She said "once you start doing it it's no big deal." She set her BP meter up in her kitchen where it was easily accessible for use, although in a couple of instances she packed it up and took it with her when she went to California or St. Louis to visit her kids. She felt that keeping track of measurements could "certainly reinforce the reasons why you would do this [measure regularly]" because the "patient wouldn't know if they didn't check." (Patient 13)</p>
<p>Patient traveled a lot during the study period, but she said that this amount of travel was unusual for her. When she was enrolled she only had one trip planned. She said it was difficult at times to be consistent with measurements/uploading because she was traveling; she said it was hard to get into a "rhythm" with so many travel-related things to do. She went out of the country three times during this period and took several domestic trips as well. On most trips she took her monitors and kept measuring but was not always able to upload. Some places she took the MetrikLink had just one telephone jack, and they would not let her use it to upload. She mentioned, "of course, when I send the data I have to stand there" and wait for it as something that was slightly annoying. She often forgot to take her BP first in the morning before doing anything else, and sometimes she had to take it right before bed. After one trip she had to take a "vacation from traveling" and stayed at the Lake of the Ozarks. During this time, she said, she was able to get in to a routine with measuring and uploading because there were "no distractions." (Patient 2)</p>
<p>Patient said tracking her measurements was a "pain in the a__" and made her feel like she was sick. Patient didn't like going through the ritual of taking and tracking her measurements and just didn't like paying that much attention to them. She also had some frustrations, such as she said the BP cuff was not always helpful—she would often get an error message on the BP cuff and have to take her BP a couple of times to get a reading. She said she might not have been as "fussy" about it if she could have sent her measurements electronically rather than finding a pencil (the patient is an avid computer user). Before, the patient was not tracking her measurements outside of what was saved on her BG meter. She had a clinic visit but forgot to bring her sheet with her; she told the MD what she was running, and he said that was ok. She feels her BPs have been pretty well controlled. Not sure she would continue doing this, it would really depend on "why" it was needed. (Patient 34)</p>
<p>She said it was hard to find a "free minute to upload" and it was just "one more thing" to add to her day to try and get done. She also cares for her handicapped mother and said doing her upload was hard to figure out how to fit into their already established routine; she feels like when she has a free minute she wants to keep it for herself. If she were going to continue this for a long time she thought that "over time it would have just been another part of the day." Patient thinks these types of systems are "wonderful." (Patient 103)</p>
<p>Sometimes it was hard to fit in with his schedule, especially in the a.m. "I have to take my daughter to school." (Patient 45)</p>
<p>Nurse and physician data are direct quotes, while patient data are from field notes.</p>
<p>A1C, glycated hemoglobin A1c; APN, advance practice nurse; BG, blood glucose; BP, blood pressure; EHR, electronic health record; I, interviewer; R, respondent; RN, registered nurse.</p>

higher pressures and more variable pressures than they had gotten with other home devices or in the office. Despite troubleshooting with patients, this remained a significant problem for some patients and seemed to affect their level of trust in the device.

*Nonintegration of your telemedicine system with your electronic health record will cause someone a lot of extra work.* A further difficulty was that the data transmission system did not integrate electronically with the practices' electronic health record. Nurses had to access the telemonitoring Web site, extract data from the Web site by cut-and-paste or transcription, summarize the data, and then create a meaningful EMR or paper message for the physician. Because the telemonitoring data did not seamlessly integrate with the EMR, nurses created work-arounds to get summarized data into the EMR and to the physician. This process could be very time-consuming.

*Assess system usability and displays: does the system give means and outliers? Alerting capabilities?.* Beyond the Web site being separate from the EMR, an additional burden for the nurses came from suboptimal Web site usability. For example, the Web site did not support designating BG values as fasting or nonfasting, which was noted as a substantial limitation. None of the interviewed physicians chose to view the Web site, so this was not an issue for them. However, their collective choice to not directly access the data, but to rely on nurses to forward patient information, represents the barrier of accessing an entirely separate system for a limited amount and type of data. This was a usability barrier that physicians, perhaps predictably, were unwilling to overcome.

## DESIGN AND UNDERSTAND THE WORKFLOW, FLOW OF INFORMATION, AND HUMAN FACTORS

*Define the flow of information and how it will affect nurse and doctor workflow.* It was anticipated that receiving data might disrupt nurse or physician workflow. Although some of the communication functions were time-consuming, the nurses viewed the overall effect on workflow as potentially positive. For example, home monitoring data collected before the clinic visit allowed the nurse and physician to concentrate on other important tasks during the visit.

Nurses indicated that they looked at uploaded data once or twice a week. They denied being overwhelmed by information and generally described the data they received as useful. However, nurses envisioned that any future larger-scale implementation would need further development of responsibilities and protocols for the flow of information and the frequency of checking information. Because rolling enrollment in the trial occurred across six practices, any one nurse usually had no more than 10 patients on the telemonitoring protocol at a time.

Physicians were less enthusiastic about the interruptions to their workflow than nurses and were concerned about how much time it might take their nurses. As is typical of many patient communications and results, data frequently arrived in the physician's inboxes at a time when the patient was not there, requiring the physician to

switch gears from his or her previous task to consider the patient and his or her telemonitoring data. Although "between-visit" care and monitoring were objectives of this study, they nevertheless create a different workflow for physicians. None of the interviewed physicians accessed the Web site. Physicians expressed a strong preference to view summarized data, rather than the raw data, and seemed to rely on the nurses to provide relevant summarized data.

*Electronic transmission of data will not eliminate the need for real-time communication and relationship building.* Although the home monitoring data were electronically transmitted to the nurses, the nurses felt the need to continue a personal relationship with the patient, often by phone. Nurses felt obligated to touch base with patients, to give either instructions or feedback or just to let the patient know that they had reviewed the data. Despite the electronic origin of the data, nurses turned to the phone rather than secure electronic messaging, perhaps because of this need for relationships or real-time communication and also because some patients were uploading by analog phone. The form of their communication may have evolved over time to be more frequently electronic.

## PREPARE AND EQUIP THE PHYSICIANS

*Educate physicians about the evidence for telemedicine monitoring and data transmission interventions.* Physicians were concerned whether there was evidence to support these activities: does it work, is it feasible, and is it needed? Physicians wondered about the evidence for effectiveness and return on investment. This theme was unique to the physicians; these concerns were not voiced by nurses or patients. This was likely due to the physician's greater perception of personal responsibility for practice revenue generation and resource use.

*Be prepared to do between-visit care and treatment adjustments.* Nurses appreciated the ability to provide "between-visit care" to their patients. They recognized the potential to eliminate unanticipated clinical changes that might occur in the 3–6 months between patient visits. In some cases, they also detected potentially important clinical changes that influenced the care of the patient. Physicians and nurses were able to closely follow patients with whom they had just made treatment adjustments. In some instances, they were able to save patients a clinic visit because they were "watching" them.

Overall, the nurses described that the uploaded data and their use of those data with the physician allowed them to provide more integrated care that flowed between the patient's home and the office. They also identified examples of efficiencies in care afforded by the system. Physicians also cited some between-visit treatment successes.

*Telemedicine interventions may not be well received by providers in a fee-for-service model.* The fee-for-service model does not compensate the physicians and their office with money, time, or resources to provide this service, potentially affecting feasibility. There was also a concern that this type of model could be implemented by other agencies, such as home health services,

potentially burdening the physician and clinic staff, again without reimbursement. Capitation-based payment systems, including accountable care organizations, may find telemonitoring to be a more financially sustainable intervention because there would be no lost income if visits were decreased or if there were fewer hospitalizations.

*Advanced practice nurses may enable the intervention through co-management strategies with the physician.* Both physicians and nurses agreed that advanced practice nurses facilitated the intervention. Upon receiving results, they could make dosage changes, often negotiating the changes with the patient in real-time, rather than having the delay of contacting the physician to make the change. The practices without advanced practice nurses cited delays in implementing changes due to the extra steps of notifying the physician, having the physician decide on an action, and receiving a return communication from the physician.

### INVOLVE THE PATIENT IN THE PROCESS

*Choose appropriate patient candidates.* After participating in the study, the nurses and physicians had very defined ideas about who might be best for this type of intervention in their usual clinical practices. The best patient candidates for this type of intervention were felt to be patients who were changing their regimen, not in optimal control, or newly diagnosed; these patients might have a greater need for close monitoring than most patients with diabetes. This trial excluded patients who had been diagnosed with diabetes for less than 1 year, so we may have excluded some of the patients who physicians and nurses thought might have benefited most. Motivated and tech-savvy patients may also be more successful or at least may find this intervention more appealing and easier to implement.

*Encourage patients to become active managers of their own care.* Nurses and physicians gave examples of the monitoring system making a difference in a patient's insight into his or her lifestyle and disease. It also helped to keep some patients more accountable to themselves in managing their own disease. Clinicians could use the data to reinforce with patients how medications and lifestyle changes affect their clinical data. Patients also recognized the value of this type of feedback, including some who viewed their numeric and graphical data online.

*Develop strategies with patients to integrate with daily life and routines.* Patients were the stakeholders most tasked with integrating the intervention into their everyday life. Accordingly, they expressed this theme more than the physicians and nurses. Patients shared their struggles and strategies for scheduling their readings and uploads around work, childcare, and travel. Because patients often had busy schedules, technology glitches were hard to tolerate.

### Discussion

Similar to other health technology innovations, implementing home telemonitoring of BP and BG may seem at first to be a simple

intervention. In practice, however, implementing such an innovation requires a series of progressive steps with each relying on the previous steps. Complicating the implementation process even further is that not all steps in the process can be foreseen at the beginning. For example, even though the researchers were aware that only the glucose meters specified by the telemonitoring vendor would be supported by the technology, there were still difficulties connecting some of these prespecified meters. In addition, connections using both phone lines and computers were sometimes complicated by unforeseen and sometimes undiagnosable obstacles. All of this has the potential to frustrate and confound the efforts of all but the most stalwart implementation champions. In many cases, patients may need a high level of baseline skill, a great tolerance for overcoming technology obstacles, or a great deal of vendor and office staff assistance.

Variations in the ability of patients and practices to overcome obstacles may lead to the inconsistent results seen in some trials of telemonitoring.<sup>24</sup> In fact, given the importance of environmental and contextual factors, it may be difficult to generalize findings of a telemonitoring trial across settings. Of particular concern is the translation of randomized controlled trials into real-world clinical practice. The structures, resources, and personnel of research trials are often quite different from those of primary care practices and are only too likely to lead to different results.

Our results also demonstrate the need for a comprehensive anticipation of stakeholder needs and preferences, as addressing the needs of one group may not satisfy the needs of another. The physicians' need to know about the evidence for these interventions is a good example. This need was not expressed at all by any of the other stakeholder groups, pointing to the importance of seeking and understanding concerns of all stakeholders prior to a technology implementation. More than other stakeholders, physicians were also more likely to be concerned about the lack of reimbursement for these services in a fee-for-service model. This concern might be mitigated with a migration to accountable care organizations or other capitated payment systems.

The nurses in four of the six practices were designated as chronic care managers, with three of the four being advanced practice nurses and the other a registered nurse. This provides important context for this study because management of chronic care patients is their chief duty. Thus, in the majority of practices, the added burden of receiving telemonitoring data was at least in line with their identified duties. This intervention would likely be met with less enthusiasm in practices where nurses have less focused or more conventional office duties. This context may also help explain why the nurses' overall opinion of the intervention was positive despite what seems like a great deal of extra work for them. Practices that do not have an established medical home model may find this intervention even more difficult to implement, again illustrating the difficulty of translating telemonitoring trials.

This study represents a snapshot in time, a time when patients used either a USB computer connection or a dedicated telemonitoring device with an analog phone line to upload BG and BP data. More seamless wireless and mobile systems are emerging. The usability characteristics of these devices may be different from those observed in

this study, although not necessarily better. Recommendations defining the flow of information will be relevant with existing and new technologies, although new models of care may change even those needs.

Careful consideration of the goals, impact, and likely obstacles of telemonitoring interventions may help organizations plan for smooth implementations. When considering the results of telemonitoring trials, an understanding of the context of the intervention will help practices decide if benefits seen in research studies will translate to real-world practice.

**Acknowledgments**

This project was supported by grants R18HS017035 and K08HS017948 from the Agency for Healthcare Research and Quality.

**Disclosure Statement**

No competing financial interests exist.

**REFERENCES**

1. Wagner EH, Austin BT, Davis C, et al. Improving chronic illness care: Translating evidence into action. *Health Aff (Millwood)* **2001**;20:64–78.
2. Phillips LS, Branch WT, Cook CB, et al. Clinical inertia. *Ann Intern Med* **2001**;135:825–834.
3. Pare G, Moqadem K, Pineau G, St-Hilaire C. Clinical effects of home telemonitoring in the context of diabetes, asthma, heart failure and hypertension: A systematic review. *J Med Internet Res* **2010**;12:e21.
4. Watson AJ, Kvedar JC, Rahman B, et al. Diabetes connected health: A pilot study of a patient- and provider-shared glucose monitoring web application. *J Diabetes Sci Technol* **2009**;3:345–352.
5. AbuDagga A, Resnick HE, Alwan M. Impact of blood pressure telemonitoring on hypertension outcomes: A literature review. *Telemed J E Health* **2010**;16:830–838.
6. Agarwal R, Bills JE, Hecht TJ, Light RP. Role of home blood pressure monitoring in overcoming therapeutic inertia and improving hypertension control: A systematic review and meta-analysis. *Hypertension* **2011**;57:29–38.
7. Boaz M, Hellman K, Wainstein J. An automated telemedicine system improves patient-reported well-being. *Diabetes Technol Ther* **2009**;11:181–186.
8. Bosworth HB, Powers BJ, Olsen MK, et al. Home blood pressure management and improved blood pressure control: Results from a randomized controlled trial. *Arch Intern Med* **2011**;171:1173–1180.
9. Cappuccio FP, Kerry SM, Forbes L, Donald A. Blood pressure control by home monitoring: Meta-analysis of randomised trials. *BMJ* **2004**;329:145.
10. McManus RJ, Mant J, Bray EP, et al. Telemonitoring and self-management in the control of hypertension (TASMINH2): A randomised controlled trial. *Lancet* **2010**;376:163–172.
11. Stone RA, Rao RH, Sevick MA, et al. Active care management supported by home telemonitoring in veterans with type 2 diabetes: The DiaTel randomized controlled trial. *Diabetes Care* **2010**;33:478–484.
12. Pare G, Jaana M, Sicotte C. Systematic review of home telemonitoring for chronic diseases: The evidence base. *J Am Med Inform Assoc* **2007**;14:269–277.

13. Wakefield BJ, Holman JE, Ray A, et al. Effectiveness of home telehealth in comorbid diabetes and hypertension: A randomized, controlled trial. *Telemed J E Health* **2011**;17:254–261.
14. Carrasco MP, Salvador CH, Sagredo PG, et al. Impact of patient-general practitioner short-messages-based interaction on the control of hypertension in a follow-up service for low-to-medium risk hypertensive patients: A randomized controlled trial. *IEEE Trans Inf Technol Biomed* **2008**;12:780–791.
15. Cottrell E, McMillan K, Chambers R. A cross-sectional survey and service evaluation of simple telehealth in primary care: What do patients think? *BMJ Open* **2012**;2:2012.
16. Turner J, Larsen M, Tarassenko L, Neil A, Farmer A. Implementation of telehealth support for patients with type 2 diabetes using insulin treatment: An exploratory study. *Inform Prim Care* **2009**;17:47–53.
17. Terschuren C, Fendrich K, van den Berg N, Hoffmann W. Implementing telemonitoring in the daily routine of a GP practice in a rural setting in northern Germany. *J Telemed Telecare* **2007**;13:197–201.
18. Jones MI, Greenfield SM, Bray EP, et al. Patients' experiences of self-monitoring blood pressure and self-titration of medication: The TASMINH2 trial qualitative study. *Br J Gen Pract* **2012**;62:e135–e142.
19. Starren J, Tsai C, Bakken S, et al. The role of nurses in installing telehealth technology in the home. *Comput Inform Nurs* **2005**;23:181–189.
20. Hovey L, Kaylor MB, Alwan M, Resnick HE. Community-based telemonitoring for hypertension management: Practical challenges and potential solutions. *Telemed J E Health* **2011**;17:645–651.
21. Lamothe L, Fortin JP, Labbe F, Gagnon MP, Messikh D. Impacts of telehomecare on patients, providers, and organizations. *Telemed J E Health* **2006**;12:363–369.
22. Starren J, Hripcsak G, Sengupta S, et al. Columbia University's Informatics for Diabetes Education and Telemedicine (IDEATel) project: Technical implementation. *J Am Med Inform Assoc* **2002**;9:25–36.
23. Wakefield BJ, Koopman RJ, Keplinger LE, Bomar M, Bernt B, Johanning JL, Kruse RL, Davis J, Wakefield DS, Mehr DR. Effect of home telemonitoring on glycemic and blood pressure control in primary care clinic patients with diabetes. *Telemed J E Health* **2014**;20:199–205.
24. Chaudhry SI, Matterna JA, Curtis JP, et al. Telemonitoring in patients with heart failure. *N Engl J Med* **2010**;363:2301–2309.

Address correspondence to:  
**Richelle J. Koopman, MD, MS**  
**Curtis W. and Ann H. Long Department of Family**  
**and Community Medicine**  
**University of Missouri School of Medicine**  
**MA306N Medical Sciences Building, DCO32.00**  
**Columbia, MO 65212**

*E-mail:* koopmanr@health.missouri.edu

*Received:* May 30, 2013

*Revised:* June 26, 2013

*Accepted:* June 27, 2013