

Home Health Monitoring: A System to Assess Motor and Cognitive Function

By Jeffrey Kaye and Tamara Hayes

Although the house call may be making a comeback, and home health services continue to be an important manage-

ment option, the model of healthcare for most Americans remains rooted in the traditional model of office- or clinic-based visits. This model is inherently limited, especially for older people.

First, getting to the office may be challenging for an older person, who may have limited mobility or rely on others for transportation. Thus, patients who rely on office-based care may develop a tendency to wait until a crisis or significant symptoms before seeking care. For this reason, clinicians seeing patients in the office setting may come to focus less on prevention or proactive healthcare and more on narrow problem-solving or crisis intervention. In such encounters, patients may not be at their best; they may be stressed, worried, forgetful, and not as organized as they could be for the visit.

Further, the information available to the clinician about intermittent visits to other providers or the pharmacy, or about laboratory results, is often fragmented or unavailable. For example, even the elemental exercise of reviewing a patient's medication may be significantly compromised in these situations.

The virtual house call.

Some of these challenges can be addressed by electronic medical-record systems, and, undoubtedly, linking medical-office

records with pharmacy and diagnostic systems will go a long way toward improving the integration of health information at the point of care. Nevertheless, the office-based practice of medicine will still be limited by the inherent brevity and episodic nature of appointments and the artificial setting in which they occur.

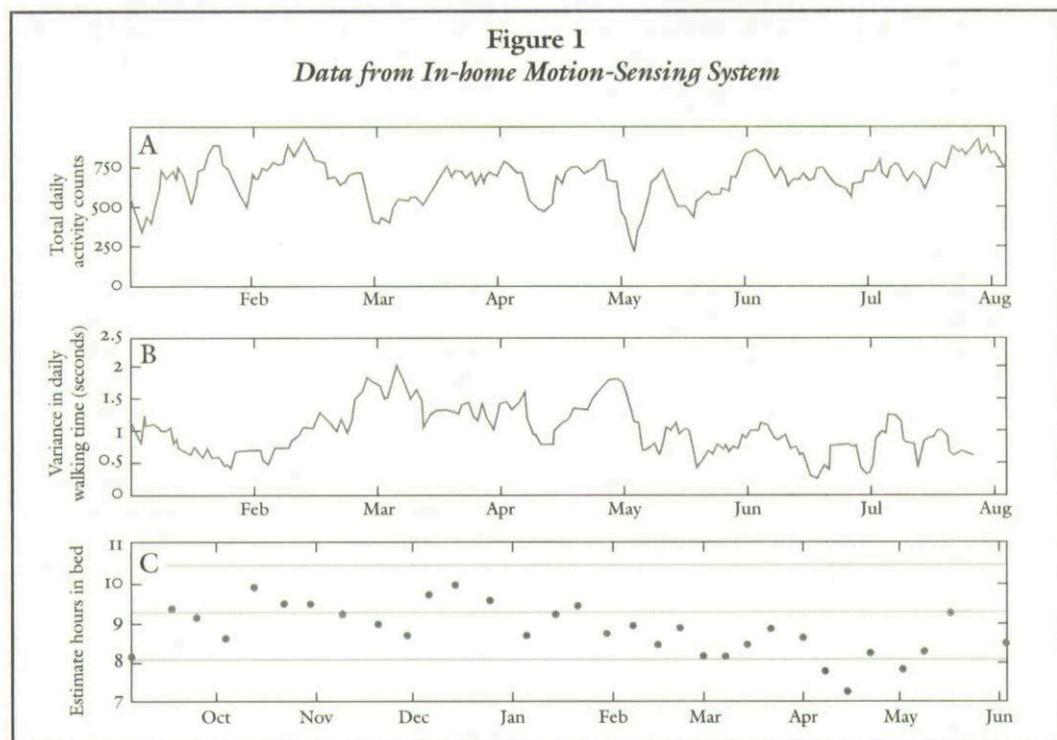
These limitations of the office visit are not restricted to the patient in crisis. Even the patient appearing for an annual checkup is not afforded the optimal evaluation in an office setting. Each visit is a single snapshot in time that essentially ignores much of the prior year, since it may be difficult for even the most cognitively intact person to remember potentially important events or trends, such as dietary habits, minor falls, medication changes, or sleep habits, especially if the individual perceives them to be unimportant. In a typical instance, a patient who had been closely followed for many years neglected to tell the physician that she had undergone an angioplasty, even though the physician had asked her on several occasions if she had any cardiac problems or surgeries. On another occa-

sion, when the physician was remarking on her good health, she simply mentioned in passing that she knew she currently had no heart problems; "I had an angioplasty a year ago."

So, bringing the office visit into the home setting provides clear advantages. As noted above, this idea is not new. Home health services have been around for quite some time and, more recently, even home-hospital models are being developed. What is new is the idea that important and relevant health monitoring can be accomplished in the home, unobtrusively, on a continuous basis. Health monitoring of the patient at home allows clinicians to collect medical or physiological data in the patient's natural environment. This type of monitoring provides the opportunity to identify both acute change and trends over time, forming the backbone of information needed for proactive, preventive healthcare. Finally, when assessment occurs in the home environment, links between health status and functional status, a key indicator of the efficacy of treatment, can be more directly observed.

A wide array of technologies and methods have been applied to home monitoring to allow

clinicians in the office to obtain information about a patient at home (Figure 1). (See the article by Rogers and Fisk in this issue.) Our view is that this work has clearly demonstrated the exciting potential of such systems for optimized healthcare. However, a major need for the field is to develop an evidence base of clinical utility on a scale typically seen in conventional clinical studies. It is necessary to go beyond the "smart home" or the demonstration pilot of early adopters to larger-scale studies with typical elders. To reach this goal, we have developed a method to provide home assessment in two key areas in which decline leads to loss of independence: motor function and cognitive function. Of course other approaches, such as more disease-focused assessments (for example, monitoring vital signs) also are important, and we anticipate incorporating a range of other functional assessment capabilities over time. For an assessment system to be widely employed, it must remain unobtrusive, easy to use, reliable, easy to maintain, and adaptable to many different home environments. Ultimately, all such home-monitoring systems are tradeoffs between these ideals and cost.



We have devised a plan for a simple, inexpensive motion-sensing system that allows for continuous monitoring of localized motion-related activity (see Figure 1) in a typical residence within a network of homes (Hayes, Pavel, and Kaye, 2004). The system consists of a network of wireless motion and contact sensors that send signals to a transceiver attached to a computer. Strategically placed sensors also can monitor walking speed. The protocol for using this simple sensor net calls for teaching elders to enter information into a home computer. The computer then forms a portal for conveying information about related motor activity (e.g., typing speed, mouse movements), as well as higher-order thinking and communication skills. More traditional cognitive assessments, done frequently, are administered with a computer-based test system that uses automatic speech-recognition technology to score responses. Finally, the system focuses on a single important activity of daily living, taking medication, which is monitored through equipment built into a plastic pillbox like those many older people use to keep track of their medicines. An instrument on the box automatically records the time of day that the lid is opened. From this information, the clinician can mon-

itor not only medication adherence but, over time, potential cognitive and behavioral change related to changes in taking medication.

This system is unique in that the continuous data derived are time-stamped, cumulative, and appropriate for trend analysis. Figure 1 shows examples of total daily activity (A), variance in walking speed (B), and time in bed (C). Not only is this information valuable for assessment of individual functional change, but it could also be a powerful way of collecting simple but rich data from large cohorts of elders to uncover new ways of looking at how older adults can age successfully in place. ❧

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REFERENCE

Hayes, T. L., Pavel, M., and Kaye, J. A. 2004. "An Unobtrusive In-Home Monitoring System for Detection of Key Motor Changes Preceding Cognitive Decline." In proceedings of the 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society. San Francisco, Calif., September.

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