Fall Prevention and Detection: How Can Technology Help?

Every year, nearly 13 million individuals over 65 years of age experience a fall, and almost 10% of those falls result in serious injuries ranging from hip fractures to head trauma[1]. A 2003 study found that nearly 1.8 million individuals were treated in emergency rooms for fall-related injuries and more than 421,000 were hospitalized for these injuries[1]. Another study found that one-quarter of individuals who fractured a hip remained in institutional care, and between 15 and 20% were dead within a year[2].

The financial consequences associated with falls are also significant. Some suggest that fall-related injuries account for 6% of all medical expenditures in the United States, and in 2000, the CDC estimated the total cost of treating fall-related injuries reached $19 billion.

All of these statistics beg an important question: How can falls be prevented more efficiently and effectively? One answer is by using technology. This article outlines what you need to know about fall prevention programs and procedures, technology's role in improving them and, most importantly, how to bring these technologies into your long-term care facilities.

HOW DO YOU PREVENT FALLS?

There are three types of interventions to reduce the risks associated with falls: primary (fall prevention), secondary (early fall detection and fall-related injury prevention), and tertiary (reduction of morbidity from fall-related injuries).

An effective primary prevention program is focused on identifying the individual and environmental risk factors associated with falls, and developing strategies to protect a person from them. Common individual risk factors include vision problems, arthritis, poor balance, and previous falls associated with health conditions.

Some environmental factors associated with falls include loose carpets, unsafe stairways, bathtubs without handles, and poor lighting. Recent studies have found that the most effective primary fall prevention programs assess these risks simultaneously. These programs are commonly focused on medication review and reduction, home-safety evaluation and modification, and chronic disease management.

TECHNOLOGY FOR PRIMARY PREVENTION

Fall Watch Alarm Technologies

Fall watch alarm technologies include bed and chair alarms, some of which are based on pressure sensitive mats/switches that are placed in the bed or chair, while others (primarily bed alarms) also integrate a weight sensor with an adjustable threshold for added reliability. When the person attempts to get out of bed, the sensor triggers an alarm that is routed through the nurse call system. Similarly, portable chair alarms with pressure-sensitive mats and/or switches operate on the same principle, and sound the alarm on the unit attached to a chair. Another type of portable bed/chair alarm comprises a small clip attached to the clothing of the patient. The clip is connected to an adjustable cord with a magnetic disk on the other end. The disk attaches magnetically to a unit that clips to a bed or chair. When the person attempts to get up, the disk is pulled away from unit, activating a magnetic switch that triggers an alarm.

Bed (upper right) and chair (below) alarms are most effective when connected to a nurse call system that can distinguish between a high fall-risk patient ambulating and less urgent patient needs.

Photo courtesy of Bed-Check Corporation

Another type of technology that can be used to promote primary fall prevention is the FallSaver device from NOCwatch International (www.fallsaver.net). This credit-card size patch, worn in a pouch on an individual's thigh, is wireless, disposable, waterproof, shockproof, and unobtrusive. The transmitter inside the pouch sends a signal from a person to a receiver in the patient's room when the patient gets out of bed or a wheelchair unassisted. This sensor detects movement when a person's leg begins to bear weight. Researchers recommend using this device with individuals with a high fall-risk assessment, a test that evaluates factors including vision, recent fall history, and walking ability. Morse fall scale[3] and Heslin fall scale[4] are two of the most popular screening tools used to identify a higher-risk population and specific risk factors.

A recent study found that using FallSaver reduced the number of falls among nursing home residents by 91%. The device was particularly effective when used among individuals with dementia. During this study, the residents and staff appeared to accept the device, and it had no adverse effects on residents' skin integrity. Using FallSaver cost the studied facility approximately $2 per day when the patches were attached directly to the patient's skin, but the cost may be lower if the patch is placed inside a person's clothing[5].

It is important to point out that bed alarm technologies are most effective when connected to a compatible nurse call system that can distinguish between

Photo courtesy of Ultimate Safety Corporation

a high fall-risk patient leaving his or her bed from a less urgent nurse call, such as one made by a patient requesting a glass of water. The nurse call system should handle the former as a high priority and sound an audibly distinct alarm signal. Also, one should consider the alarm system's sensitivity (its reliability in detecting bed/chair exits) and its specificity (its rate of false alarms).

TECHNOLOGY FOR SECONDARY PREVENTION

Hip Protectors

Secondary intervention devices like hip protectors are effective in reducing a fall's impact, but residents may resist them, as they perceive the protectors to be bulky and cumbersome. Studies have found that protectors do reduce hip fractures, however, because elders may not always wear the products, the overall fracture risk may not be reduced.

Safe Floors

Researchers at Pennsylvania State University developed a flooring system that provides a stable walking surface that also deforms elastically under higher loads, such the weight and impact of a fallen person. Their analysis of the system found that this flooring would reduce the impact on a person's femoral neck during impact by 15.2%. Conversely, the flooring would be expensive, and some institutional building codes related to flooring material in assisted living facilities would prevent further testing and use. More recently, researchers from New Zealand have seemingly succeeded in further reducing the impact force in their shock-absorbing floor prototypes. Such protective flooring systems are not on the market yet. In the meantime, using bed/chair alarms and lowering beds can be effective in preventing falls and reducing fall injuries respectively.

WHAT TYPES OF FALL DETECTION TECHNOLOGIES ARE AVAILABLE?

Four types of fall-detection technologies are available commercially or under development:

- User-activated alarms and pendants
- Automatic wearable fall detectors
- Video-monitoring-based fall detectors (under development)
- Floor-vibration-based fall detectors (under development)

User-Activated Alarms and Pendants

These devices require users to activate an alarm button on a pendent or bracelet integrated with a wireless transmitter. When pressed, the button activates a medical alert unit connected to a telephone that calls a monitoring center. A center attendant will immediately speak to the user and contact their designated loved ones or care providers.

A number of long-term care facilities and community alarm centers, including Philips Life Line, BLEEP, and LifeFone, offer this technology to facilities for a nominal monthly monitoring fee. Although such fall alarms are simple and low-cost, they are not effective if a person is unable to activate the alarm, takes it off, or forgets to activate it. In selecting a user-activated alarm or pendant for residents, consider the device's range from the phone unit, as well as its level of reliability and potential for inadvertent activation of false alarms.

Automatic Wearable Fall Detectors

Automatic detectors use accelerometers to detect a fall's impact and tilt sensors and/or gyroscopes to determine a person's position after the fall. There are many designs of automatic detectors available, and they should be worn above the resident's waist as a neck pendant, bracelet, or strap connected to their belt or pocket.

A fall detector must be worn where it will assume the body's inclination following a fall. Provided the device is fixed to the resident's clothing at or above the waist, it will measure the body's inclination within an acceptable tolerance of 10 to 15 degrees, and will detect more than 90% of all falls onto a horizontal floor. An alarm, however, may not be triggered if a person's torso does not assume a horizontal inclination. For example, if a person's slump to the ground is interrupted by furniture or stairs, the fall detector would be activated, but may not sense that the person has fallen to the ground. Some automatic fall detectors also have a button that the wearer can push to call for help in the unlikely event that the fall detector is not automatically activated.

Generally, these devices are small, inexpensive and are available on a "plug and play" basis for anyone who has a community alarm telephone and alarm monitoring service. It is important to remember that the devices are only effective if they are worn correctly whenever the resident is up and about. Here

Photo courtesy of NOCwatch International Inc.

The FallSaver System from NOCwatch detects movement when a person's leg begins to bear wieght.

again, ensure that the device has an adequate range from the alarm phone unit to meet the resident's needs, and be sure it is sufficiently reliable and has a low rate of false alarms.

Video-Monitoring-Based Fall Detectors

These devices track individuals' activities using installed cameras and attempt to detect a fall event based on image-processing algorithms designed to identify unusual inactivity. Universities worldwide are conducting research in the development of video-analysis-based fall-detection systems, in order to explore the variations in image-processing algorithms and monitoring/ transmission systems.

Generally, all video-based fall-monitoring systems have the potential to detect falls with no user intervention. However, the fear of intrusion of privacy is more prominent with camera-centric technologies. In spite of using a low-quality imaging or on-site image processing, the residents may still feel like they are being "watched," based on their perceptions of the sensor. Because of their intensive computations, these technologies are more expensive than others. These technologies may also be more difficult to implement than other available technologies.

Floor-Vibration-Based Fall Detectors

This class of fall detectors is currently under development. The energy associated with impact as a result of a fall is picked up via vibration sensors coupled to the floor. One of the recent fall detector prototypes in this category was developed by the University of Virginia's Medical Automation Research Center (MARC). The detector continuously monitors the floor for vibrations produced by activities like walking, sitting down, and falling. MARC conducted preliminary laboratory tests to evaluate the technology's effectiveness with dummies, and the initial results were encouraging. This technology may come to market in about a year.

WHAT DOES THE FUTURE HOLD FOR FALL PREVENTION TECHNOLOGY?

Advances in material sciences and information technology would help fall prevention and detection technologies become more effective, affordable, and less invasive for users and providers. All of these improvements, however, are contingent on more support for research that aims to assess the technology's impact and its potential to improve the aging experience and reduce the cost of care.

WHAT CAN LONG-TERM CARE FACILITIES DO TODAY?

Facilities may consider launching an internal quality review around falls, implementing fall risk assessments, and engaging their frontline caregivers in needs assessments that aim to identify the primary underlying causes of falls in the facility, as well as potential solutions, including appropriate technologies. If the identified solution is technological, an objective, quantitative field evaluation of the technology's reliability, sensitivity, and specificity, as well as its potential impact on outcomes, such as fall incidence rates, your caregivers, and your operations should be conducted prior to the mass deployment of the technology. ■

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- *To learn more about CAST's work with fall prevention and other technologies, visit www.agingtech.org.*

References:

1. WISQARS [database online]. Atlanta, Ga: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2005. Updated April 06, 2007.
2. Magaziner J, Hawkes W, Hebel JR, et al. Recovery from hip fracture in eight areas of function. *Journal of Gerontology*: Medical Sciences. 2000;55A(9):M498–507.
3. Morse, JM, Morse R, Tylko S. Development of a scale to identify the fall-prone patient. *Canadian Journal on Aging*. 1989;8(4):366-377.
4. Heslin K, Towers J, Leckie C, et al. Managing falls: identifying population specific risk factors and prevention strategies. In: Funk S, Tornquist E, Champagne M, Weise R, eds. *Key Aspects of Elder Care: Managing Falls, Incontinence, and Cognitive Impairment*. New York: Springer Publishing; 1992:70-88.
5. Kelly, KE, Phillips, CL, Kain KC, Polissar, NL, Kelly PB. Evaluation of a nonintrusive monitor to reduce falls in nursing home patients. *J Am Med Dir Assoc*. 2002;3:377–382.

WHERE TO FIND Hip Protectors:		
Vendor	**Website**	**Reader Service Number**
CuraMedica, LLC	www.curamedica.com	78
HipSaver	www.hipsavers.com	79
Plum Enterprises, Inc.	www.plument.com	82
Posey Company	www.posey.com	83
Prevent Products, Inc.	www.preventproducts.com	84
Tytex Group	www.tytex.com	85
WHERE TO FIND Bed/Chair Alarms:		
210 Innovations	www.safetmate.com	86
Alimed, Inc.	www.alimed.com	87
Bed-Check Corporation	www.bedcheck.com	88
Care Electronics, Inc.	www.medicalshoponline.com	89
Curbell Electronics	www.curbell.com	90
Nurse Assist, Inc.	www.rnplus.com	91
Personal Safety Corporation	www.psc.nu	92
Pioneer Medical Systems, Inc.	www.pioneermed.com	93
Posey Company	www.posey.com	94
RF Technologies	www.rft.com	96
Smart Caregiver Corporation	www.smartcaregivercorp.com	97
Stanley Senior Technologies	www.seniortech.com	98
Tunstall Group Ltd.	www.tunstallamerica.com	99
Ultimate Safety Corporation	www.ultimatesafety.com	100
Universal Medical Products	www.u-m-p.com	101