Outcomes of Patient-Engaged Video Surveillance on Falls and Other Adverse Events

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KEYWORDS

• Surveillance • Falls • Fall prevention • Outcomes • Patient engagement • TeleSitting

KEY POINTS

- Patient-engaged video surveillance is effective in reducing falls, room elopement, and line, tube, or drain dislodgement.
- Formal, trained 24-hour monitoring is more effective in reducing falls than sitters, bed alarms, and purposeful rounding.
- Constant observation and individualized patient interaction decreases the burden of staff response to false alarms and alarm fatigue.
- Across all adult age groups, patients respond positively to patient-engaged video surveillance.
- Data and fact-based outcomes of patient-engaged video surveillance on falls and other adverse events are explored.

INTRODUCTION

The continued burden of hospital-acquired adverse events on patient loss of function and life requires that all health care organizations stop surveillance practices that create a false sense of safety. This article summarizes current knowledge about patient surveillance integrated into clinical practice and patient safety outcomes in the hospital setting. Evidence of the efficiency and effectiveness of traditional surveillance system measures such as call bells, bed alarms, and intentional rounding lacks methodologic rigor. The integration of such technology for all patients, irrespective of

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cognitive status, increases unnecessary burden to the nursing workforce and fails to individualize patient safety prevention. Health care leaders, in efforts to fast track patient safety improvement, are investing in patient-engaged video surveillance (PEVS) technology that ensures patient and family engagement, patient care privacy, individualized care planning, and workforce safety. This article presents the results of continuous PEVS on patient falls, room elopement, and line, tube, or drain dislodgement across 71 hospitals between June 1, 2017, and May 31, 2018.

SLOW PROGRESS IN REDUCING PATIENT HARM

The slow progress in reducing the burden of hospital-acquired harm requires that organizations must commit to transforming patient safety practices.[1] The inpatient population's vulnerability to harm has increased, and interdisciplinary teams fail to implement reliable patient safety interventions based on vulnerability. In 2010, 45% of the inpatient hospital population in the United States was 65 years of age and older, among whom 19% were ages 75 to 84 years of age and 9% were 85 years of age and older. These findings should compel all organizations to implement patient safety programs based on increased vulnerability to hospital-acquired harm that results in loss of function or loss of life. For example, falls in persons 85 years of age and older are the leading cause of unintentional injury death.[2] Levant and associates[2] urged organizations to intentionally correct root causes of harm, which is best achieved when root causes are observed and reported.

Since 2010, Centers for Medicare & Medicaid Services have provided funding for health organizations to implement patient safety practices that decrease patient harm, as monitored by scorecards reported by the Agency for Healthcare Research and Quality.[3] A new national goal for 2017 was to decrease harm 20% overall by 2019. The Agency for Healthcare Research and Quality in 2018 released the newest scorecard data on gains in patient safety by reducing hospital-acquired conditions. In 2015 and 2016, the results reported an 8% decline in all hospital-acquired conditions.[4] It is well-known that falls in hospitals are high volume and high cost. Prior research has confirmed that 3% to 20% of patients in hospitals fall at least once[5] and of those who fall, 30% to 51% are injured.[6] In 2017, The Joint Commission reviewed a total of 805 sentinel alerts. Falls were the second highest reported sentinel alert (n = 114). From 2014 to the second quarter of 2017, fall sentinel events were the third top reported harm event in the nation, preceded only by unintended retention of a foreign body, and by wrong patient, wrong site, or wrong procedures.[7] The slow reduction of adverse conditions, particularly falls—and, ultimately, injurious falls—confirms that current practices are ineffective. Data do not exist on harm to patients owing to line, tube, or drain dislodgements or eloping from their room.

AVAILABLE KNOWLEDGE

Keeping patients safe in their rooms within clinical units is still predominately the responsibility of nursing staff. For decades, nurses have relied on traditional surveillance methods to proactively meet patient needs: hourly rounding, patient-activated call lights, and movement-initiated alarms. Recently, these methods have been supplemented by cameras installed in rooms in the intensive care unit or emergency department psychiatry holding areas, allowing anyone at a nurses' station to observe patients. The ineffectiveness of these traditional interventions is confirmed by a limited number of published studies and the epidemic of harm still occurring in hospitals.

Evidence reviews report that hourly rounding leads to improved patient satisfaction, decreased fear, improved perceptions in nursing care, decreased call light use, and

decreased aggregated fall rates.[8] However, these studies lack methodologic rigor in the form of inconsistent reporting of the quantity, quality, and reliability of rounding. The association with decreased fall rates is not linked to the specific type of fall prevention intervention, nor is it aligned with the specific type of fall (eg, an accidental or anticipated physiologic fall).

Both patient use of call lights, a universal tool, as well as nurse responsiveness have been linked to patient care satisfaction and safety. Tzeng and colleagues[9] reported a relationship between faster call light response time and decreased fall rates and injurious fall rates. The average call light response time across 4 hospitals was 13 minutes and 18 seconds. The hospital with the longest response time was 17 minutes and 27 seconds. Patients can successfully exit a bed or chair and fall during this time interval. Among patients included in their study, 9.93% of patients admitted had altered mental status and could not reliably use a call light. The total fall rate was 4.08 per 1000 patient-days. Total injurious falls was 0.91 per 1000 patient-days. The percent of patients 65 and older was 35.93%.

Movement alarms are among the most commonly used fall prevention strategies in hospitals.[10] In research on these alarms, the most commonly used outcome measure is number of falls,[11] percent of fallers,[12] or fall rates.[12,13] Studies on patients rescued from experiencing a fall, and on the reduction in falls, fallers, or fall rates are very limited. Furthermore, there are no published studies on the timeliness of nursing staff response to patients' activated alarms.

PATIENT-ENGAGED VIDEO SURVEILLANCE

Video surveillance is a common intervention method used to monitor people and processes throughout industries. Use in hospitals has predominately been in emergency room holding areas and intensive care units. PEVS is a more interactive form of video surveillance, with dedicated and trained staff using a hospital workstation to monitor multiple patients simultaneously. Through a 2-way audio communication system, a monitoring staff member verbally engages with the patient. Monitoring staff become familiar with patients' behavioral patterns and can proactively intervene before patients attempt risky behaviors such as getting out of bed without assistance. Monitoring staff can verbally redirect patients, contact caregivers, and trigger an alarm if necessary. Patients are selected for PEVS based on bedside clinical assessment. Patients most at risk for falls and other adverse events often have an impaired mental status. Published articles on PEVS show effective outcomes in decreasing overall fall and injury rates. Preventing falls through the selection and observation of the most at-risk patients impacts overall hospital and/or care unit fall and injury rates.[14–18] These studies also show effective outcomes in cost savings through reducing falls, falls with injuries, and one-to-one sitter costs. Although the outcomes are consistent, the sample sizes of patients enrolled in PEVS has remained small, limited by the number of purchased monitors (ie, Cournan and colleagues[18] reported only 15 patient monitors with 1 monitor tech in a 115-bed hospital). Data collection was dependent on manual data collection from monitor staff. There have been no studies measuring the timeliness of rescue (ie, clinical response time to PEVS alarms).

Design

A descriptive study based on large-scale program evaluation data was conducted to answer the following research questions:

1. What is the age distribution of the adult population enrolled in PEVS? What is the duration of PEVS?

2. Do trends in verbal patient engagement, alarm rate, and alarm response time vary by age group?
3. Does the rate of adverse events (fall, room elopement, and line, tube, or drain dislodgement) vary by age group?
4. Do differences exist by patient age, monitor staff engagement, and response time, and do these differences impact fall rates?
5. What is the potential cost savings difference between PEVs and 1:1 sitter usage?

Methods

Across all 71 hospitals, the same PEVS system was implemented. Data were collected from the national data reporting system. The program implemented was AvaSys®, a telehealth solution that includes a monitoring device, which is either permanently installed or mobile, in the patient's room. AvaSys transmitted an audio–video feed across each hospital's secured wireless network to a workstation where 1 trained monitoring staff member interacted with up to 16 patients at once. The primary bedside nurse selected appropriate patients for PEVS, based on nursing judgment and hospital-specific policies, and worked with the monitor staff to set up and individualize PEVS. Patients were deemed high risk for an adverse event based on factors such as altered mental status, acuity, agitation, and impaired mobility. During surveillance, the monitoring staff learned the patient's behaviors and verbally engaged the patient before adverse events occurred. The bedside caregivers were also able to request a virtual privacy screen during personal patient care. In the case of an urgent or emergent observed behavior, a PEVS alarm was triggered. The top 3 adverse events prevented were assisted and unassisted falls, room elopement, and line, tube, or drain dislodgement.

Measures

Data collection

Data were captured automatically from PEVS into a national database as video monitoring staff observed and intervened. The data were stored securely via cloud for ease of data export and analysis with RStudio®. The 71 participating hospitals in this study were selected based on the presence of intervention data logging and patient age. All participating hospitals had an executed agreement allowing for the analysis and publication of aggregate data. On a monthly basis, AvaSure, LLC (Belmont, MI), securely exported raw data from the hospitals' servers. This data did not contain protected health information, as defined by the Safe Harbor method.[19] The data were then aggregated to provide program metrics and national benchmarking for subscribers.

Key Metrics

Monitoring staff software interactions were automatically captured to provide the following patient engagement metrics.

- Verbal interventions: occurrences of monitoring staff using the talk button to speak directly to patients.
- PEVS alarm: occurrences of monitoring staff activating the alarm.
- Alarm response time: a measure of the amount of time elapsed between activation and deactivation of the PEVS alarm.

The software also allowed monitoring staff to report which of their interventions likely avoided an adverse event, with a brief description of the circumstances. The top 3 reported adverse events included the following.

- Fall: When a fall is observed, monitoring staff immediately report the fall event witnessed and whether it was an assisted or unassisted fall. They do not report falls with injury, because monitoring staff are not qualified and do not have enough information to determine if an injury has occurred with a fall.
- Elopement: Monitoring staff report when a patient leaves the threshold of his room. They do not, however, report when a patient leaves the hospital building because they are not able to observe outside of the patient's room.
- Line, tube, or drain dislodged: Monitoring staff report if a patient dislodges a medical device such as a peripheral intravenous catheter, Foley catheter, or nasal cannula.

The adverse event rate is calculated by dividing the number of adverse events by days of surveillance on PEVS and multiplying by 1000. This rate is consistent with national standards for the reporting of fall rates per 1000 patient-days.

Results

Between July 1, 2017, and May 31, 2018 there were 15,021 patients 18 years of age or older; these patients were monitored for a total of 942,482 hours (39,270 patient-days). The average length of surveillance was 62.7 hours (Table 1). On average, monitoring staff talked to patients 15.8 times per patient day (616,006 total verbal interventions) and activated 1.6 alarms per patient day (61,003 total alarms). The average alarm response time was 15.8 seconds (Table 2). The observed reported adverse events included a total of 59 falls witnessed by monitoring staff during PEVS: 44 (75%) were unassisted falls and 15 (25%) were assisted. None of the patients fell more than once; thus, the number of patients who fell was 59. Adults younger than 65 years old were more likely to fall during surveillance than patients 65 years or older ($P = .002$). The oldest age group (≥85 years old) experienced the lowest rate of falls per 1000 days of surveillance (0.38). There were 106 incidents of dislodgement that occurred. The oldest age group also experienced the lowest rate of line, tube, or drain dislodgements per 1000 days of surveillance (2.30). Twenty-seven patients eloped from their rooms. Patients between the ages of 65 and 84 years had the lowest elopement rate per 1000 patient-days (0.42; Table 3). The overall fall rate was 1.50 falls per 1000 days of surveillance, and the unassisted fall rate was 1.12 unassisted falls per 1000 days of surveillance. The number of room elopements and the number of line, tube, or drain dislodgements was also reported per 1000 days of surveillance (Table 4).

Patients who experienced a fall had 20.5 verbal interventions per patient day, compared with 15.7 verbal interventions per patient day for those who did not fall ($P = .0005$). The falling group also had a higher number of alarms than the nonfalling

Table 1
Patient-engaged video surveillance patient age and use

	Age (y)			
Factors	**18–64**	**65–84**	**≥85**	**Total**
No. of patients	5173	6393	3455	15,021
Hours	359,584	395,392	187,506	942,482
No. of patient-days	14,983	16,475	7813	39,270
Length of surveillance (h/d)	69.5/2.9	61.8/2.5	54.3/2.3	62.7/2.6

Data collected from June 1, 2017, to May 31, 2018 from 71 hospitals.

Table 2
Patient engagement interventions

	Age (y)			
	18–64	65–84	≥85	Total
No. of patients	5173	6393	3455	15,021
No. of verbal interventions	223,207	270,869	121,930	616,006
No. of PEVS alarms	21,081	26,113	13,809	61,003
Verbal interventions per patient-day	14.9	16.4	15.6	15.8
PEVS alarms per patient-day	1.4	1.6	1.8	1.6
Average PEVS alarm response time (s)	17.7	14.8	14.7	15.8

Abbreviation: PEVS, patient-engaged video surveillance.
Data collected from June 1, 2017, to May 31, 2018 from 71 hospitals.

group, namely, 2.38 and 1.55, respectively ($P = .01$). PEVS alarm response time for patients who experienced unassisted falls was slower at 19.2 seconds, as compared with the aggregate response time of 15.8 seconds ($P = .07$).

There were 453 annualized full-time equivalents that would be required to provide 942,482 hours of surveillance by the traditional one-to-one sitter method. With PEVS provided at a monitoring staff to patient ratio of 1:12, the total number of required full-time equivalents is reduced by 92% to 38 full-time equivalents. The actual cost savings are contingent on the hourly wages of the one-to-one sitters and monitoring staff.

There were no differences in alarm or verbal intervention rates between the 3 age groups. Somewhat less engagement from monitoring staff, as measured by verbal interventions and alarm rates, was noted for patients 65 years old or younger. Bedside caregivers were noted to respond more slowly to alarms from patients in the youngest age group.

Discussion

Over 1 year, clinical nurses from 71 hospitals selected 15,021 patients they believed were at greatest risk for falls and other adverse events. Studying the outcomes of PEVS on this group of high-risk patients gives a new window into understanding the effectiveness of PEVS. Estimating the anticipated fall rate had the 15,021 patients

Table 3
Monitoring staff reported adverse events

	Age (y)			
	18–64	65–84	≥85	Total
No. of patients	5173	6393	3455	15,021
Total falls	34	22	3	59
Unassisted falls	26	16	2	44
Assisted falls	8	6	1	15
Elopements (from patient room)	14	7	6	27
Line, tube, or drains dislodged	40	48	18	106
Total adverse events	122	99	30	251

Data collected from June 1, 2017, to May 31, 2018 from 71 hospitals.

Table 4
Adverse event rates per 1000 days of surveillance

	Age (y)			
	18–64	65–84	≥85	Total
Total falls per 1000 days of surveillance	2.27	1.34	0.38	1.50
Assisted falls per 1000 days of surveillance	0.53	0.36	0.13	0.38
Unassisted falls per 1000 days of surveillance	1.74	0.97	0.26	1.12
Elopements per 1000 days of surveillance	0.93	0.42	0.77	0.69
Line, tube, or drains dislodged per 1000 days of surveillance	2.67	2.91	2.30	2.70

Data collected from June 1, 2017, to May 31, 2018 from 71 hospitals.

received traditional fall prevention interventions without PEVS would be difficult because the same protocol for patient selection was not used across all the hospitals. The fact that the overall fall rate was only 1.50 falls per 1000 days of surveillance demonstrates the effectiveness of PEVS. It is especially encouraging to see that the fall rate in the oldest age group (≥85 years of age), which is most vulnerable to fall injury, was only 0.38 falls per 1000 days of surveillance.

The findings of our study should impress on all organizations the confirmed positive contribution that innovative technology is making on patient safety for the adult population. Traditional fall prevention programs are failing to prevent falls, and progress toward reducing falls in an aging patient population has been slow. Our study shows that continuous observation and timeliness of response are key factors in preventing falls. These results also support population-based selection criteria based on clinical risk factors for falls and injury risk, not merely a score on a fall risk screening tool. Health care organizations should implement policies for patient selection based on vulnerability, such as protecting those 85 years of age or older, with confusion or impulsivity from falls. Then clinical training programs for constant observation and patient engagement would be population specific.

Our study adds to the body of evidence suggesting that timeliness of response is a key factor in preventing falls. It was noted that patients who fell while on PEVS had a statistically significant longer alarm response time than patients who did not fall while on PEVS (19.2 seconds and 15.8 seconds, respectively). This means that just 3.4 seconds can make all the difference in rescuing a patient from a fall. The results of our study provide original data on how quickly a patient can experience a fall. Even within an extremely rapid alarm response time of seconds, fall events did occur.

Again, compare this outcome with the work of Tzeng and colleagues,[9] whose data were discussed elsewhere in this article and demonstrated a relationship between faster call light response time and decreased fall rates and injurious fall rates. However, their call light response time average, of 13 minutes and 18 seconds, is more than 10 times longer than responses times in PEVS alarms reporting. Their study also reported a higher fall rate than the reported PEVS fall rate (4.08/1000 patient-days and injurious falls 0.91/1000 patient-days). The fact that call light response time averages are more than 10 times longer than PEVS alarm response time averages should be a significant consideration for organizations entrusted with patient care and safety. The results of our study add evidence suggesting that timeliness of response is a key factor in preventing falls.

Interestingly, it was also noted that, although verbal interventions and alarms were close to the same rate in the 65 to 84 year old range and the 85 years and older age range, there were far fewer falls in the older age group ($P = .008$; **Fig. 1**. This finding

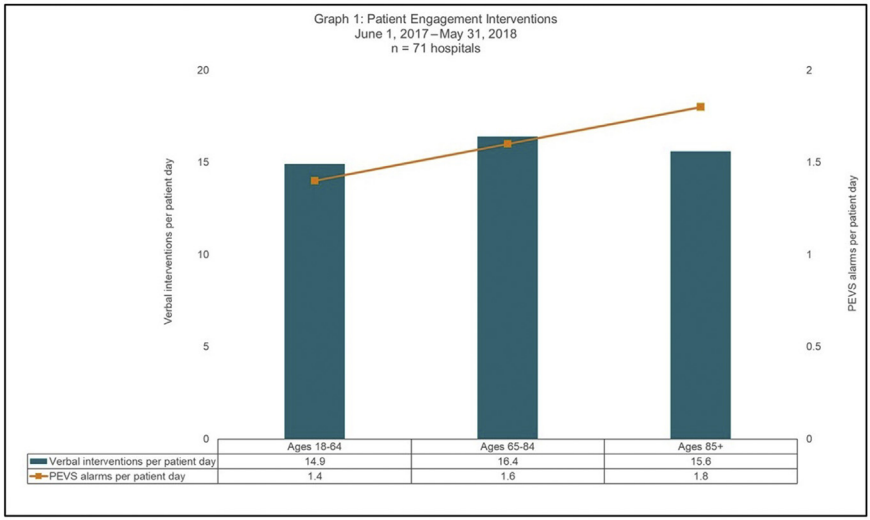

Fig. 1. Patient engagement interventions from June 1, 2017, to May 31, 2018 at 71 hospitals. PEVS, patient engaged video surveillance.

may indicate that older adults take longer to get to a standing position,[20] allowing more time for nursing staff to respond and prevent the fall. However, this finding does not decrease the need for timeliness of response to alarms in preventing patient falls. Indeed, see Jones and colleagues,[20] who established age-specific values, based on biomechanical research and quantified within 30 seconds, for adults of varying ages completing cycles of standing from a sitting position and sitting back down—referred to as sit-to-stand cycles. The time for each cycle provides insight into how quickly a fall can occur from a chair. An older adult between the ages of 65 and 69 can complete between 11 and 16 sit-to-stand cycles within 30 seconds (taking 2.72 seconds for each sit-to-stand cycle, and 1.88 seconds for each stand-to-sit cycle). A person between 85 and 89 years of age can perform 8 to 13 sit-to-stand cycles within 30 seconds (for a slower individual, 3.75 seconds for 8 cycles in 30 seconds; or for a faster individual, 2.30 seconds for 13 cycles in 30 seconds). It would take a person more seconds to transition from lying to sitting to standing, or fewer seconds if he were to roll out of bed onto the floor.

Considering this discussion, our results showing that PEVS increases rapid nurse response are significant for organizations seeking to implement patient safety programs based on increased vulnerability. PEVS promotes rapid nurse response because, when monitor technicians see an urgent or emergent patient need, they activate the PEVS alarm. Used only when patients are in imminent danger of an adverse event, the PEVS alarm is recognized by unit nursing staff as signaling an urgent need and thus elicits a quick response within seconds to the bedside.

The results of our study also showcase the variations in patient safety for the oldest of patients—patients who are 85 years of age or older. Data showed that monitoring staff used slightly fewer verbal interventions and slightly more PEVS alarms for the patient population 85 years of age or older—a patient population with a higher likelihood of experiencing increased confusion and/or difficulty hearing. If monitor staff decreased their verbal interventions for these reasons, perhaps even per nursing staff instruction, monitor staff would have a higher incidence of needing to call nursing staff

to the patient's bedside with an alarm. This factor could perhaps account for the findings of our study showing that bedside caregivers are quicker to respond to older patient populations. Responding quickly to older patients is a best practice in age-specific fall and injury prevention that is protective. Our findings confirm that nursing staff implemented age-specific care.

These findings become critically important when viewed alongside other data. For example, consider the original research conducted by Levant and colleagues,[2] in 2015, who explored the epidemiology of the aging of the inpatient hospital population from 2000 to 2010, with special focus on persons 85 year of age and older. They found that, in 2010, 45% of the inpatient hospital population in the United States was 65 years of age and older, among whom 19% were ages 75 to 84 years old and 9% were at least 84 year old. Furthermore, consider that falls are the leading cause of unintentional injury deaths in adults 85 and older. These findings should compel all organizations to implement patient safety programs based on increased vulnerability.

Last, clinical decision-making tools within organizations should be further differentiated for the selection of sitter use versus purposeful rounding with PEVS, because the indications may be redundant for select populations. The need exists for comparison of PEVS, sitter use, and/or purposeful rounding. Organizations should define clear selection criteria and training programs for the nursing staff.

Limitations

One limitation to point out is that, during PEVS implementation, all hospitals received the same implementation training program for monitoring staff and nursing staff support. However, hospitals were allowed to modify their protocol for patient selection and enrollment. For example, 1 hospital implementation committee could select to enroll neurologic and rehabilitation patients, whereas another hospital could select to enroll medical/surgical and orthopedic units. Control for unit types and acuity was not possible. Therefore, the analysis to risk adjust based on acuity was not possible.

A second limitation in our study is in regard to the top 3 observed adverse events reported. In the case of room elopement and line, tube, or drain dislodgement, no comparison of national rates can be made between organizations using PEVS and those not using PEVS because these adverse events are not reported to national public comparison databases.

A third limitation in our study is estimating the anticipated fall rate had the 15,021 patients received traditional fall prevention interventions instead of PEVS fall prevention interventions. The overall fall rate of 1.50 falls per 1000 days of surveillance demonstrates the effectiveness of PEVS. It is especially encouraging to see that the fall rate in the oldest age group, namely, those 85 years of age and older, who are most vulnerable to injury, the fall rate was 0.38 falls per 1000 days of surveillance.

Finally, it is worth pointing out that the success of any patient care plan depends on an organization's culture, reliability of implementation, staff attitude, and fidelity to capturing accurate and meaningful data on effectiveness and efficiency.

MORE RESEARCH NEEDED

More research is needed on PEVS engagement activities, such as verbal interventions and alarm rates, and their impact on outcomes as well as patient selection. This study is the first to capture elopement from room and create a rate for observed line, tube, or drain dislodgement. With constant patient observation as implemented in PEVS, organizations can better document the true scope or adverse events occurring during

patients' hospitalization. More research is needed to understand patient selection for adverse events that occur in patient rooms, including but not limited to self-harm attempts and violence against caregivers. With the vast opportunity in this field, it will be exciting to see future research outcomes.

An important piece of our findings is that in just 1 year of measuring patients on PEVS, for an average length of stay of less 3 days of surveillance, the fall rate and the rate of fall reduction with PEVS far exceeds the aggregate fall and fall rate reduction among all of the hospitals enrolled in Centers for Medicare & Medicaid Services Hospital Engagement Network/Hospital Innovation Improvement Networks (2010–2014).

The data from our study show the rapid contribution of PEVS technology on patient safety. The incidence of falls, room elopement, and line, tube, or drain dislodgement that happened for patients selected for PEVS were rare. The safety net provided by PEVS is so expansive that the many additional prevented adverse events reported through this program are beyond the scope of this article. PEVS allows monitoring staff to see and correct unsafe environments by alerting nursing staff, redirecting patients to stay in bed because a nurse is on the way to help, observing respiratory distress, recognizing the signs of delirium, and much more. With the data observed and reported through implementing PEVS technology, organizations are best positioned to correct root causes of harm and create a real-time, broad safety net for patients.

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