Improving Patient Safety through the Use of Nursing Surveillance

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About the Author

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Abstract

Surveillance and monitoring each represent a distinct process in patient care. Monitoring involves observation, measurement, and recording of physiological parameters, while surveillance is a systematic, goal-directed process based on early detection of signs of change, interpretation of the clinical implications of such changes, and initiation of rapid, appropriate interventions.

Through use of an illustrative clinical example based on Early Warning System scoring and rapid response teams, this article seeks to distinguish between nurse monitoring and surveillance to demonstrate the impact of surveillance on improving both care processes and patient care.

Using a clinical example, differences between surveillance and monitoring as a trigger for deployment of the rapid response team were reviewed. The use of surveillance versus monitoring resulted in a mean reduction in rapid response team deployment time of 291 minutes. The median hospital length of stay for patients whose clinical care included using surveillance to initiate the deployment of the rapid response team was reduced by 4 days.

Monitoring relies on observation and assessment while nursing surveillance incorporates monitoring with recognition and interpretation of the clinical implications of changes to guide decisions about subsequent actions. The clinical example described here supports that the use of an automated surveillance system versus monitoring had a measurable impact on clinical care.

Hospital leadership must establish, implement, and oversee standards of care and continually re-evaluate care processes in order to provide high-quality care for more diverse and high-acuity-level patient populations. Strategies to improve the quality of care, prevent or reduce adverse events, and ensure equitable access to quality care include the use of computerized decision support systems, improved measurement and reporting efforts, and the increased use of patient monitoring and surveillance.[1] Surveillance improves patient care through appropriate assessment, interpretation, and use of information to guide individualized care management.[1] The appropriate use of surveillance can provide an important foundation for improving the quality of patient care and reducing avoidable medical errors.

Avoidable medical errors and adverse events of varying severity are estimated to cause more than 1 million patient injuries[2] and tens of thousands of deaths[2–6] annually. Adverse events affect nearly one in seven inpatients in the United States[7] and result in more deaths than breast cancer or acquired immunodeficiency syndrome.[5] Analysis of a nationally representative random sample of Medicare beneficiaries revealed that 13.5% of hospitalized patients have experienced an adverse event. That is equivalent to 134,000 patients affected by a serious error each month. An additional 13.5% of Medicare beneficiaries experienced events resulting in temporary harm that required

medical intervention with almost one-half of medical errors deemed preventable.[7]

The rates of preventable adverse events and the quality of healthcare vary by geographic region,[8–11] healthcare system,[12–14] and patient populations,[13,15–20] with diverse factors contributing to these variations. Patients experience more complex health problems and are at higher risk of becoming seriously ill while hospitalized.[21] Furthermore, patients once considered medically fragile are undergoing complex surgical and medical interventions, which places them at greater risk for adverse events.[22] There is an increased need for higher-acuity inpatient beds with ward nurses to care for patients who previously would be admitted to critical or intensive care units (ICUs).[23] The mix of nursing skills, nurse-to-patient ratios, and bed shortages also affect quality of care.[22,24]

This article seeks to clarify the distinctions between patient monitoring and surveillance and to discuss the unique roles of surveillance and monitoring in patient care with a focus on the strengths and limitations of each process. The potential impact of nursing surveillance on patient safety and clinical outcomes is illustrated using a case example based on Early Warning System (EWS) scoring and rapid response teams and systems (RRTSs).

Surveillance Versus Monitoring in Clinical Care

Various terms describe the work of nurses in the identification of clinical changes indicative of clinically relevant changes in a patient's condition.[22,25] Florence Nightingale was among the first to associate monitoring with nursing care. She described monitoring as a patient observation with the goal of data collection to save lives, prevent harm, and improve outcomes. This description was refined to "an assessment process in which clinicians observe, measure, and record patient data."[26,27] Perhaps the most obvious example of monitoring is the assessment of patient vital signs, which is a nursing function performed for more than 100 years[28] and initially focused on five parameters: temperature, respiration rate, oxygen saturation, blood pressure, and heart rate.[28] The list of essential vital signs was recently expanded to include monitoring levels of consciousness, pain, and urine output.[22,29]

Nurses rely on vital sign assessment to monitor patients and identify unfavorable changes in their clinical condition, often before observing objective evidence of deterioration. Surveillance combines patient monitoring with active observation, analysis of information, and interpretation of relevant findings.[30–34] Failure to monitor and process observed information contributes to poor clinical management, including delays to diagnosis, treatment, or referral; suboptimal assessment; and inadequate or inappropriate management. Such compromises in care can carry serious consequences, including admission to critical care units, cardiac arrest, prolongation of hospital stay, and death.[35–37] Recent data support that failures in both monitoring and surveillance are the primary root cause of unplanned ICU admissions.[38] Surveillance can be distinguished from monitoring by its purpose, approach, data sources, and analysis (Table 1).

Monitoring does not include the cognitive, analytic, and decision-making skills that are essential elements of clinical surveillance.[39] Patient monitoring is a crucial element but not the only aspect of surveillance. Monitoring primarily focuses on observing, measuring, and recording physiological parameters. All hospitalized patients require some level of manual or automated monitoring.[40] Surveillance is more appropriately applied to patients for whom monitoring provides data indicative

All hospitalized patients require some level of manual or automated monitoring.

Criteria	Surveillance	Monitoring
Criteria component of nursing process	A nursing intervention; classified by the Nursing Intervention Classification System; the intervention, surveillance, involves a variety of activities including monitoring.	A nursing assessment; not included in the nursing Intervention Classification System.
Purpose	Early identification of risk; The need for intervention and to alert nurses to both anticipated and unanticipated changes in patient's condition; Goal-direct, based on patient's risk and current status.	Alert nurses to both anticipated and unanticipated changes in patient's condition.
Approach	Nurse systematically and selectively attends to factors in an appropriate sequence and at the correct time depending on specific needs of patient.	Nurses engage in generic approach that is applied to all patients regardless of diagnosis, typically as part of unit standard (e.g., monitoring every 2 hours).
Data sources and analysis	Diverse data sources are used, including the patient's family and environment; Includes ongoing data analysis to support clinical decisionmaking.	Data are primarily physiological; Data may be analyzed only as needed (e.g., if a change arises in a patient's condition).

Table 1. Comparison of surveillance and monitoring

of changes in clinical status and who need further evaluation and possible intervention. Three monitoring domains are associated with nursing surveillance: diagnostic monitoring, therapeutic monitoring, and monitoring to manage rapidly changing clinical situations.[39]

Routine patient monitoring is an increasingly important strategy for detecting subtle changes in a patient's status to ensure appropriate interventions are implemented before those changes evolve into a serious event. Monitoring is a continuous and comparative process of patient care, which includes an evaluation component that distinguishes it from simple patient observation.[40] Nurses compare data obtained through monitoring with previously collected information and normative values. This comparative evaluation facilitates recognition of potential complications and changes in clinical status. Nurses routinely monitor vital signs and assess clinical status, with or without the assistance of automated machines, at intervals based on illness severity.[41] However, monitoring does not integrate the analytic and decision-making skills that are essential elements of nursing surveillance.[27]

Surveillance is a systematic and goal-directed process focused on the early detection of the signs of deterioration, recognition of changes, and initiation of rapid and appropriate interventions.[27,42] More specifically, surveillance includes evaluation of monitoring parameters *plus* the acquisition, integration, and interpretation of information from other sources, including family members, other members of the healthcare team, medical databases, and clinical decision support systems.[26,42,43] The essential components of nurse surveillance include ongoing observation, recognition, interpretation, and decision making (Figure 1).[44]

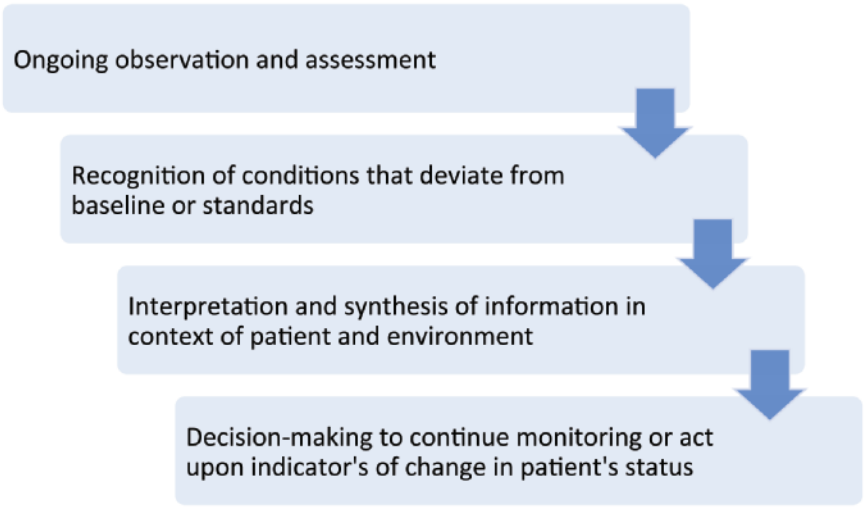

Figure 1. The components of nurse surveillance, in which nurses monitor, evaluate, and act upon emerging indicators of a patient's change in status.

Ongoing observation includes physical and mental examinations, identification of changes in physiological, cognitive or behavioral status,[45] and evaluation of laboratory findings, medications, adverse effects, and drug interactions.[26,42] Observed changes in the patient's status are interpreted as evidence of increasing risk or a desired response to medical interventions.[44]

Recognition is the ability to identify patient conditions that deviate from baseline measurements, normative standards, or parameters of interest established at the time of the initial patient assessment. Informative indicators of changes in patient status include vital signs, neurological and mental status, cardiac and respiratory functioning, and laboratory results.[44]

Interpretation logically follows observation and recognition of changes in patient status. It requires that nurses synthesize information within the context of individual patients and their environment while relying upon critical thinking, experience, and clinical judgement.[42,44]

Decision making, the final component of surveillance, requires that nurses decide to continue monitoring or take actions in response to observed change(s) in the patient's status. Such actions can include modifications to the care plan, communication with other members of the healthcare team, and mobilization of resources to address emerging clinical needs.[42,44]

When performed properly, surveillance allows nurses to identify patients at risk for unfavorable clinical outcomes and potential adverse events, as well as to interrupt and correct medical errors. Nurses interpret information within the full context of the patient's physical, emotional, and mental status and share it with all members of the care team.

Importantly, surveillance is a repeated, regular, and ongoing process conducted by multiple nurses as they monitor their patient's condition around the clock.[42,44] When performed within the overall context of all patient variables, surveillance may improve early identification of patients who are at risk for

unexpected deterioration, which can prevent serious complications, adverse events, medical errors, and death.[42]

Example of Nursing Surveillance: Early Warning Systems

The deterioration of patients outside the critical care unit usually presents as a progressive physiologic decline over several hours rather than occurring as a sudden onset.[46–51] Patients frequently exhibit physiologic signs of instability in the respiratory, cardiovascular, and/or neurological systems, which can be measured by routine monitoring. This may result in serious deterioration, which clinicians could have recognized and treated earlier if they used surveillance to assess and interpret data provided by routine monitoring at the onset.[46–51]

Patients receiving care in low-acuity areas are monitored intermittently according to individual hospital practices and standards. This can result in overlooking changes in physiologic status that provide an early indication of imminent and potentially preventable serious adverse events (e.g., an in-hospital cardiac arrest).[46–51] A retrospective evaluation of the association between the number of abnormal vital signs and in-hospital mortality demonstrated that 59.4% of patients experienced at least one abnormal vital sign 1 to 4 hours before experiencing an in-hospital cardiac arrest and 13.4% experienced one or more severely abnormal vital sign. Mortality rates increased as the number (odds ratio 1.53 [95% CI 1.42–1.64]) and severity (1.62 [1.38–1.90]) of pre-arrest abnormal vital signs rose.[35]

Rapid Response Teams and Systems

Missed opportunities for early intervention based on changes in monitored vital signs and patient status are the impetus for development and implementation of RRTSs. An RRTS consists of a group of clinicians who can be deployed at any time to bring critical care expertise to patients at any hospital location, ensuring timely delivery of appropriate treatment and prevention of patient deterioration. The RRTS model was implemented in diverse healthcare systems, including Australia, Canada, the United Kingdom, and the United States.[52–55]

Surveillance may improve early identification of patients who are at risk of deterioration, which can prevent complications, adverse events, medical errors, and death.

RRTSs and automated alerts of declines in clinical status are associated with lower hospital mortality, fewer cardiopulmonary arrests, reductions in non–critical care unit cardiac arrests and unplanned ICU transfers, and decreased hospital length of stay.[52,53,55–58] RRTSs are also associated with reduced rates of cardiac arrest prior to transfer to ICUs,[59] reduced incidence of cardiopulmonary arrests,[60] increased survival immediately after RRTS treatment, and increased survival to discharge.[54] A meta-analysis reported that RRTSs significantly reduced in-hospital mortality rates in adult (risk ratio 0.87 [95% CI 0.8–0.95], $P < 0.001$) and pediatric (0.82 [0.76–0.89]) inpatient populations. Cardiopulmonary arrests in adult (0.65 [0.61–0.70]) and pediatric (0.64 [0.55–0.74]) general ward patients were also significantly reduced.[55] Importantly, delays in RRTS activation were independently associated with increased rates of patient mortality and unfavorable morbidity outcomes.[61]

Early Warning System scores do not predict outcomes or direct clinicians' actions. Rather, the scores indicate that patients may be deteriorating and in need of clinical intervention.

Early Warning Systems

The optimal use of RRTSs requires quantitative criteria to guide patient assessment for deterioration and trigger timely interventions. Various iterations of EWS scoring were developed to more reliably identify at-risk patients and trigger appropriate clinical interventions.[62] Such systems are based on the premise that physiological changes detected by a combination of various parameters provide a more comprehensive clinical picture of patient deterioration or instability compared with changes in any single parameter.

Although hospitals vary in their exact methods for calculating EWS scores and triggering the RRTS, the typical physiologic parameters include heart rate, respiratory rate, blood pressure, temperature, and urine output. EWS typically generates RRTS trigger scores by allocating points to a list of physiologic parameters based on deviations from accepted "normal" ranges. The score for each parameter is summed, which yields a composite score that estimates a patient's level of risk for an unfavorable outcome. When the total exceeds a prespecified value, RRTS members are alerted to a potentially deteriorating condition.

Importantly, EWS scores do not predict outcomes or direct clinicians' actions. Rather, the scores indicate that patients may be deteriorating and in need of clinical interventions and/or additional surveillance. As nurses work to achieve early identification of patients at risk for deterioration, monitoring provides the data source for EWS scoring. Surveillance of monitored data triggers interventions to prevent or treat patient deterioration before the situation becomes life threatening. Nursing staff compile the patient's clinical picture and initiate actions or continue monitoring and care based on their interpretation of EWS scores.

Surveillance Versus Monitoring

A total of 157 inpatients admitted to two general medical-surgical wards in a large teaching hospital were evaluated. RRTSs were the standard of care for all patients, with criteria for activating the team shown in Table 2.

The criteria consisted primarily of vital signs monitored by nurses or nursing assistants as part of routine patient care. An EWS score of 2 prompted initiation of additional monitoring

	Early Warning System Score						
Criteria	**3**	**2**	**1**	**0**	**1**	**2**	**3**
Heart rate (bpm)	<39	40–44	46–59	60–100	101–119	120–124	>130
Systolic blood pressure (mmHg)	<80	81–89	90–99	100–150	151–174	175–199	>200
Respiratory rate (breaths/min)	<5	6–8	9–11	12–20	21–25	26–29	>30
Temperature (°F)	<94	94.1–94.9	95–96.7	96.8–100.6	100.7–101.5	101.6–103.9	>104
SpO2 (%)	<87	88–92	92–95	96–100	—	—	—

Table 2. Criteria and associated Early Warning System score

and surveillance while scores of 3 or greater resulted in calls to the RRTS to provide further patient evaluation and treatment (Figure 2). All patients in the sample reported EWS scores that triggered RRTS calls.

In the 87 patients where the EWS score was manually calculated, vital signs were collected intermittently and manually. The EWS score was calculated manually based on each set of vital signs, with the total score determining subsequent actions. This method of patient assessment relied primarily on monitoring but not surveillance. The nurses or nursing assistants obtained and recorded patient vital signs. However, the monitored vital signs were not consistently evaluated against prior measurements or institutional standards at the time of assessment.

Vital signs were also collected intermittently in the 70 patients where care was provided using surveillance. However, the automated system was integrated with the patient monitors used to obtain vital signs. Calculation of EWS scores was performed automatically each time vital signs were taken, which allowed ongoing and automatic comparisons with previous vital signs. In addition, visible alerts were provided at the point of care whenever the combination of vital signs resulted in a score that met or exceeded the criteria for alerting the RRTS. This method of assessment required nurses to interpret visible alerts and make a determination about the need for RRTS intervention as soon as the vital signs were taken. This met the criteria of observation, recognition, interpretation, and decision making, which are essential to nursing surveillance.

Impact

A review of basic patient demographics found no differences in the clinical acuity, medical/surgical case mix, age, gender, or number of vital signs taken between the patients who were cared for using surveillance versus monitoring. The mean time for nurses to call the RRTS for the patients using surveillance was 152 minutes, and the mean time for patients using monitoring only was 443 minutes. In addition, median hospital length of stay for patients in the EWS group using monitoring was 14 days compared with 10 days for patients who were cared for using surveillance.

Discussion

Nursing surveillance is a complex, multidimensional process with the potential to optimize patient management, reduce treatment delays, and improve safety. The hallmark of nursing surveillance is "purposeful and ongoing acquisition, interpretation, and synthesis of patient data [to support] clinical decision making."[40] Monitoring is more than simple patient observation. It incorporates evaluation and use of different methods to collect and accumulate patient data and compare these data to standard values. Monitoring is an essential element of surveillance. However, monitoring alone does not incorporate data analysis, interpretation, and decision-making skills, all of which are essential elements of surveillance.

Clinical surveillance is based on the premise that there is no single measure or measurement method in patient care. Surveillance requires the ability to perceive and recognize relationships and similarities in multiple clinical measures and identify threats and risks to the patient's well-being. Surveillance also requires more intense participation by caregivers. A vast array of technologies are both available and under development for use in surveillance. Thus, improvements in patient safety require an organizational commitment to invest in technologies and care processes that can support surveillance.[63]

A systemwide approach to clinical surveillance promotes awareness of safety within an organization and encourages all caregivers to assume proactive roles in the interpretation of data collected through monitoring. Daily

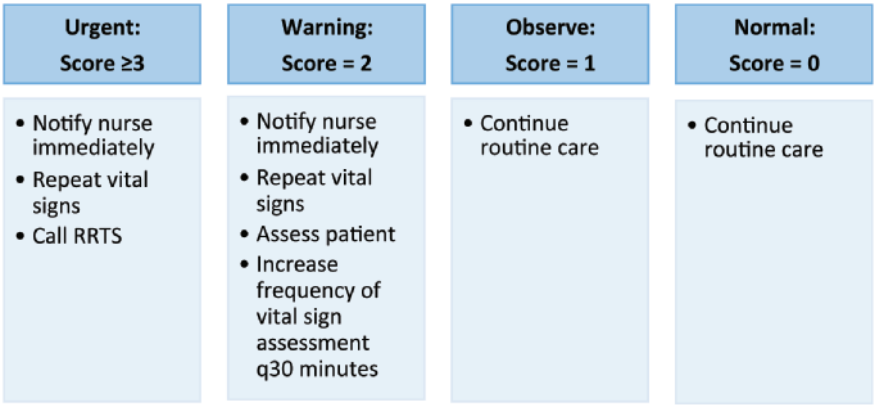

Figure 2. A description of actions to be taken by frontline caregivers based on score derived from an Early Warning System.

Successful surveillance requires ongoing training to ensure an understanding of systems, develop the ability to idenfity threats, identify clinical triggers, and contribute to efforts to improve clinical care and safety.

opportunities exist for learning as data is recognized, interpreted, and acted upon countless times for multiple patients during a single shift. Successful surveillance requires ongoing training to ensure an understanding of systems, develop the ability to identify threats, identify clinical triggers, and contribute to efforts to improve clinical care and safety. The reliability of surveillance activities and systems must be evaluated and improved continuously to achieve meaningful and sustained improvements in patient safety and clinical outcomes in an efficient and cost-effective manner.[63]

The clinical example described here highlights differences in the clinical values of surveillance versus monitoring. The most relevant difference was that the automated EWS supported surveillance by providing each patient's score for real-time evaluation by nursing staff. This prompted actions immediately following vital sign monitoring for each patient, resulting in a shorter time-to-treatment. These findings are consistent with recent data, which found that implementing a Modified Early-Warning Scoring (MEWS) system without a clear surveillance protocol was associated with only 1% of patients having a correctly documented MEWS score and delayed recognition of patient deterioration.[38]

Conclusion and Implications for Future Research

Monitoring is characterized by ongoing patient observation and assessment. Nursing surveillance uses the results of monitoring to recognize changes in the patient's clinical status, interpret the clinical implications of these changes, and decide if actions are required. The case example supports the use of an automated surveillance system to improve care. Future research should focus on the implementation and evaluation of technology and processes that can facilitate the use of surveillance in acute care settings. ■

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Ethical Approval

The data used in this study was approved for use by the Institutional Review Board at Orlando Regional Medical Center, Orlando, FL.

References

1. **National Committee for Quality Assurance.** The Essential Guide to Health Care Quality. 2014. Available at: www.ncqa.org/Portals/0/Publications/Resource%20Library/NCQA_Primer_web.pdf. Accessed Nov. 28, 2015.
2. **Leape LL, Brennan TA, Laird N, et al.** The Nature of Adverse Events in Hospitalized Patients. Results of the Harvard Medical Practice Study II. *N Engl J Med*. 1991;324(6):377–84.
3. **Institute of Medicine.** *Keeping Patients Safe: Transforming the Work Environment of Nurses.* Washington, DC: National Academies Press; 2004.
4. **James JT.** A New, Evidence-Based Estimate of Patient Harms Associated with Hospital Care. *J Patient Saf*. 2013;9(3):122–8.
5. **Kohn LT, Corrigan JM, Donaldson MS.** *To Err Is Human: Building a Safer Health System.* Washington DC: National Academies Press; 1999.
6. **Leape LL.** A Systems Analysis Approach to Medical Error. *J Eval Clin Pract*. 1997;3(3):213–22.
7. **Department of Health and Human Services.** Adverse Events in Hospitals: National Incidence among Medicare Beneficiaries. Washington DC: Office of Inspector General; 2010.
8. **Finkelstein A, Gentzkow M, Williams H.** Sources of Geographic Variation in Health Care: Evidence from Patient Migration. *Q J Econ*. 2016;131(4):1681–1726.
9. **Fisher ES, Wennberg JE.** Health Care Quality, Geographic Variations, and the Challenge of Supply-Sensitive Care. *Perspect Biol Med*. 2003;46(1):69–79.

10. **Ogunniyi MO, Holt JB, Croft JB, et al.** Geographic Variations in Heart Failure Hospitalizations Among Medicare Beneficiaries in the Tennessee Catchment Area. *Am J Med Sci*. 2012;343(1):71–7.

11. **Sundmacher L, Busse R.** Geographic Variation in Health Care. *Health Policy*. 2014;114(1):3–4.

12. **Institute of Medicine.** *Geographic Variation in Spending, Utilization and Quality: Medicare and Medicaid Beneficiaries*. Washington, DC: National Academies Press; 2013.

13. **Tsai TC, Orav EJ, Joynt KE.** Disparities in Surgical 30-day Readmission Rates for Medicare Beneficiaries by Race and Site of Care. *Ann Surg*. 2014;259(6):1086–90.

14. **Wennberg JE, Freeman JL, Shelton RM, et al.** Hospital Use and Mortality Among Medicare Beneficiaries in Boston and New Haven. *N Engl J Med*. 1989;321(17):1168–73.

15. **Asch SM, Kerr EA, Keesey J, et al.** Who Is at Greatest Risk for Receiving Poor-Quality Health Care? *N Engl J Med*. 2006;354(11):1147–56.

16. **Baicker K, Chandra A, Skinner JS.** Geographic Variation in Health Care and the Problem of Measuring Racial Disparities. *Perspect Biol Med*. 2005;48(suppl):S42–53.

17. **Jha AK, Fisher ES, Li Z, et al.** Racial Trends in the Use of Major Procedures Among the Elderly. *N Engl J Med*. 2005;353(7):683–91.

18. **Singh JA, Lu X, Ibrahim S, et al.** Trends in and Disparities for Acute Myocardial Infarction: An Analysis of Medicare Claims Data from 1992 to 2010. *BMC Med*. 2014;12:190 [eCollection].

19. **Trivedi AN, Zaslavsky AM, Schneider EC, et al.** Trends in the Quality of Care and Racial Disparities in Medicare Managed Care. *N Engl J Med*. 2005;353(7):692–700.

20. **Wegman M.** Differences in Quality of Care by Payer. *Health Aff (Millwood)*. 2014;33(1):181.

21. **Ryan H, Cadman C, Hann L.** Setting Standards for Assessment of Ward Patients at Risk of Deterioration. *Br J Nurs*. 2004;13(2):1186–90.

22. **Elliott M, Coventry A.** Critical Care: The Eight Vital Signs of Patient Monitoring. *Br J Nurs*. 2012;21(10):621–5.

23. **Butler-Williams C, Cantrill N, Maton S.** Increasing Staff Awareness of Respiratory Rate Significance. *Nurs Times*. 2005;101(27):35–7.

24. **Butler M, Collins R, Drennan J, et al.** Hospital Nurse Staffing Models and Patient and Staff-Related Outcomes. *Cochrane Database Syst Rev*. 2011;(7):CD007019.

25. **Rogers A, Dean G, Hwang W, et al.** Role of Registered Nurses in Error Prevention, Discovery and Correction. *Qual Saf Health Care*. 2008;17(2):117–21.

26. **Henneman EA, Gawlinski A, Giuliano KK.** Surveillance: A Strategy for Improving Patient Safety in Acute and Critical Care Units. *Crit Care Nurse*. 2012;32(2):e9–18.

27. **Kelly LA.** Nursing Surveillance in the Acute Care Setting: Latent Variable Development and Analysis [dissertation]. Phoenix, AZ: The University of Arizona; 2009.

28. **Ahrens T.** The Most Important Vital Signs Are Not Being Measured. *Aust Crit Care*. 2008;21(1):3–5.

29. Lewis R. Vital Signs Are Vital for a Reason. *Nurs Stand*. 2012;26(51):72.

30. **Douw G, Schoonhoven L, Holwerda T, et al.** Nurses' Worry or Concern and Early Recognition of Deteriorating Patients on General Wards in Acute Care Hospitals: A Systematic Review. *Crit Care*. 2015;19:230 [eCollection].

31. **Goldhill DR, McNarry AF.** Physiological Abnormalities in Early Warning Scores Are Related to Mortality in Adult Inpatients. *Br J Anaesth*. 2004;92(6):882–4.

32. **Goldhill DR, McNarry AF, Mandersloot G, et al.** A Physiologically-Based Early Warning Score for Ward Patients: The Association Between Score and Outcome. *Anaesthesia*. 2005;60(6):547–53.

33. **Harrison GA, Jacques T, McLaws ML, et al.** Combinations of Early Signs of Critical Illness Predict in-Hospital Death: the SOCCER Study (Signs of Critical Conditions and Emergency Responses). *Resuscitation*. 2006;71(3):327–34.

34. **Odell M, Victor C, Oliver D.** Nurses' Role in Detecting Deterioration in Ward Patients: Systematic Literature Review. *J Adv Nurs*. 2009;65(10):1992–2006.

35. **Andersen LW, Kim WY, Chase M, et al.** The Prevalence and Significance of Abnormal Vital Signs Prior to in-Hospital Cardiac Arrest. *Resuscitation*. 2016;98(9):112–7.

36. **DeVita MA, Smith GB, Adam SK, et al.** "Identifying the Hospitalised Patient in Crisis"—A Consensus Conference on the Afferent Limb of Rapid Response Systems. *Resuscitation*. 2010;81(4):375–82.

37. **Quirke S, Coombs M, McEldowney R.** Suboptimal Care of the Acutely Unwell Ward patient: A Concept Analysis. *J Adv Nurs*. 2011;67(8):1834–45.

38. **van Galen LS, Struik PW, Driesen BE, et al.** Delayed Recognition of Deterioration of Patients in General Wards Is Mostly Caused by Human Related Monitoring Failures: A Root Cause Analysis of Unplanned ICU Admissions. *PloS One*. 2016;11(8):e0161393.

39. **Benner P.** Creating a Culture of Safety and Improvement: A Key to Reducing Medical Error. *Am J Crit Care*. 2001;10(4):281–4.

40. **Dougherty DM.** Surveillance. In: Bulechek GM, McCloskey JC (Eds.). N*ursing Interventions: Effective Nursing Treatments*. Philadelphia, PA: Saunders; 1999. 524–32.

41. **Schmidt PE, Meredith P, Prytherch DR, et al.** Impact of Introducing an Electronic Physiological Surveillance System on Hospital Mortality. *BMJ Qual Saf*. 2015;24(1):176–7.

42. **Dresser S.** The Role of Nursing Surveillance in Keeping Patients Safe. *J Nurs Adm*. 2012;42(7–8): 361–8.

43. **Henneman EA, Gawlinski A, Blank FS, et al.** Strategies Used by Critical Care Nurses to Identify, Interrupt, and Correct Medical Errors. *Am J Crit Care*. 2010;19(6):500–9.

44. **Kutney-Lee A, Lake ET, Aiken LH.** Development of the Hospital Nurse Surveillance Capacity Profile. *Res Nurs Health*. 2009;32(2):217–28.

45. **Zeitz K.** Nursing Observations During the First 24 Hours After a Surgical Procedure: What Do We Do? *J Clin Nurs*. 2005;14(3):334–43.

46. **Buist M, Bernard S, Nguyen TV, et al.** Association Between Clinically Abnormal Observations and Subsequent in-Hospital Mortality: A Prospective Study. *Resuscitation*. 2004;62(2):137–141.

47. **Duncan KD, McMullan C, Mills BM.** Early Warning Systems: The Next Level of Rapid Response. *Nursing*. 2012;42(2):38–44.

48. **Franklin C, Mathew J.** Developing Strategies to Prevent in Hospital Cardiac Arrest: Analyzing Responses of Physicians and Nurses in the Hours Before the Event. *Crit Care Med*. 1994;22(2):244–7.

49. **Gardner-Thorpe J, Love N, Wrightson J, et al.** The Value of Modified Early Warning Score (MEWS) in Surgical In-patients: a prospective observational study. *Ann R Coll Surg Engl*. 2006;88(6):571–5.

50. **Hodgetts TJ, Kenward G, Vlachonikolis IG, et al.** The Identification of Risk Factors for Cardiac Arrest and Formulation of Activation Criteria to Alert a Medical Emergency Team. *Resuscitation*. 2002;54(2):125–31.

51. **Schein RM, Hazday N, Pena M, et al.** Clinical Antecedents to in-Hospital Cardiopulmonary Arrest. *Chest*. 1990;98(6):1388–92.

52. **Bellomo R, Ackerman M, Bailey M, et al.** A Controlled Trial of Electronic Automated Advisory Vital Signs Monitoring in General Hospital Wards. *Crit Care Med*. 2012;40(8):2349–61.

53. **Kollef MH, Chen Y, Heard K, et al.** A Randomized Trial of Real-Time Automated Clinical Deterioration Alerts Sent to a Rapid Response Team. *J Hosp Med*. 2014;9(7):424–9.

54. **Kollef MH, Heard K, Chen Y, et al.** Mortality and Length of Stay Trends Following Implementation of a Rapid Response System and Real-Time Automated Clinical Deterioration Alerts. *Am J Med Qual*. 2017;32(1):12–18.

55. **Maharaj R, Raffaele I, Wendon J.** Rapid Response Systems: A Systematic Review and Meta-Analysis. *Crit Care*. 2015;19:254 [eCollection].

56. **Buist MD, Moore GE, Bernard SA, et al.** Effects of a Medical Emergency Team on Reduction of Incidence of and Mortality from Unexpected Cardiac Arrests in Hospital: Preliminary Study. *BMJ*. 2002;324(7334):387–90.

57. **Chen J, Ou L, Hillman K, et al.** The Impact of Implementing a Rapid Response System: A Comparison of Cardiopulmonary Arrests and Mortality Among Four Teaching Hospitals in Australia. *Resuscitation*. 2014;85(9):1275–81.

58. **Ludikhuize J, Brunsveld-Reinders AH, Dijkgraaf MG, et al.** Outcomes Associated With the Nationwide Introduction of Rapid Response Systems in The Netherlands. *Crit Care Med*. 2015;43(12):2544–51.

59. **Goldhill DR, Worthington L, Mulcahy A, et al.** The Patient-At-Risk Team: Identifying and Managing Seriously Ill Ward Patients. *Anaesthesia*. 1999;54(9):853–60.

60. **DeVita MA, Braithwaite RS, Mahidhara R, et al.** Use of Medical Emergency Team Responses to Reduce Hospital Cardiopulmonary Arrests. *Qual Saf Health Care*. 2004;13(4):251–4.

61. **Barwise A, Thongprayoon C, Gajic O, et al.** Delayed Rapid Response Team Activation Is Associated With Increased Hospital Mortality, Morbidity, and Length of Stay in a Tertiary Care Institution. *Crit Care Med*. 2016;44(1):54–63.

62. **Ludikhuize J, Smorenburg SM, de Rooij SE, et al.** Identification of Deteriorating Patients on General Wards; Measurement of Vital Parameters and Potential Effectiveness of the Modified Early Warning Score. *J Crit Care*. 2012;27(4):424:e7–13.

63. **Thomas EJ.** The Future of Measuring Patient Safety: Prospective Clinical Surveillance. *BMJ Qual Saf*. 2015;24(4):244–5.